REFINER
AND NATURAL GASOLINE MANUFACTURER

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Two Big Reasons Why WAR *makes this the*

FOR YOU — 3 TIMES FASTER COOLING TOWER DELIVERY

FOR THE NATION — COUNTLESS MAN-HOURS AND TONS OF CRITICAL MATERIALS SAVED

A Statement of Fact Concerning Cooling Towers Made as a Contribution to Increasing War Production in Your Plant and to Benefit the Nation's War Effort. This is Why Atmospheric Cooling Towers Should Be Specified Today!

FLUOR manufactures Mechanical Draft *and* Aerator Atmospheric Type Cooling Towers. We hold no brief for *either* type, recognizing only the fact that each has its own well-defined field of application. Full recognition of these well-defined fields is *vital to Victory!* In this interest, these facts are published.

In recent years, a pronounced and largely "fashionable" trend has developed toward Mechanical Draft Cooling Towers. Demonstrable facts adequately support the statement that *in approximately 75% of the cases where Mechanical Draft types are being installed, Atmospheric Cooling Towers will render identical service with identical thermal efficiencies!* Beyond pointing out these facts, Fluor previously held no brief against this trend, but this is *WAR!* The saving of critical materials, man-hours, machine-hours, power and energy are now definite deposits to the account of Victory!

Read carefully the comparative table of savings on the opposite page. When Atmospheric Cooling Towers are specified, in the cases where they are the *correct* rather than the "fashionable" specification, tons of strategic materials will be released for offensive War. You will save a large percentage of the prime labor required for assembly of your tower, as well as secondary labor used in the manufacture of fans, gears, motors, switches, flexible couplings and electric wiring in addition to the materials from which they are made. In tower operation, you will save and conserve electric power. The sum total of the material, man-hours, machine-hours, power and energy saved constitutes a substantial contribution to the offensive War effort—*without the slightest concession in Cooling Tower efficiency!*

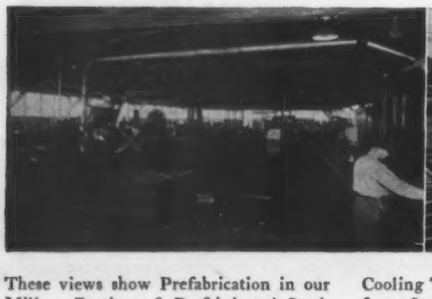
When to Specify Atmospheric Cooling Towers

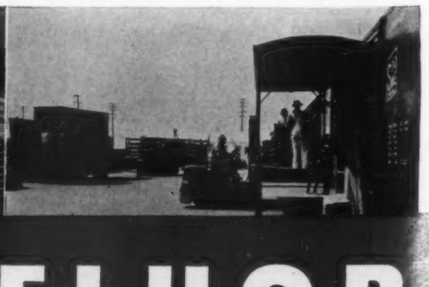
This is the rule for *correct* rather than "fashionable" Cooling Tower specification: *Atmospheric Cooling Towers should be specified in all instances excepting those where restricted space or subnormal wind conditions make the use of Mechanical Draft types imperative!* Our engineers will assist, basing their recommendations not on bias but on fact with tower efficiency as the sole objective.

Why Fluor Atmospheric Deliveries Are Three Times Faster

Delivery of Fluor Atmospheric Cooling Towers is three times faster! In the majority of instances, Fluor today is delivering Aerator Atmospheric Cooling Towers ready for fast erection *before our customers have completed foundation basins!* This is due not only to the fact that there is no delay waiting for fans, gears, motors, etc. It is due to Fluor standardization of Cooling Tower Design which makes 100% prefabrication possible. Only Fluor completely prefabricates in a mill with lumber flowing constantly down a production line to finished section storage and thence direct to you. There is no lost time; no waste motion. Your order is filled promptly direct from prefabricated Cooling Tower Section stocks.

For speed in erection, Fluor-trained erection crews are maintained near your plant. Upon completion of the basin, they are ready to swing into action and your tower is in operation in the shortest possible time—another advantage of Fluor prefabrication and standardization. Before you specify a Cooling Tower, consult our engineers and—*Be Sure With Fluor!*





These views show Prefabrication in our Mill, a Portion of Prefabricated Stock ready for Shipment from Storage and Shipment of Fluor Aerator Atmospheric Cooling Towers by Rail and Truck direct from Stock for Fast Field Erection by Fluor-Trained Crews Stationed in all parts of the Country.

FLUOR

VOLUME 21, No. 5 MAY, 1942

REFINER
AND NATURAL GASOLINE MANUFACTURER

A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

NOW that the synthetic-rubber program has been raised to 800,000 tons per year with the Buna type to have 700,000 tons, the prospect for its accomplishment deserves consideration. Also there is an effort being made to add another 300,000 tons for civilian use.

How It Looks From Here

The following analysis is part of a contribution to the bulletin of Arthur D. Little, Inc.:

"The petroleum industry operates on such a scale that the annual requirements of perhaps 600,000 tons of butadiene, butene, styrene, etc., for rubber ingredients can be absorbed as a minor item, that is, less than 1 percent of the production of gasoline, even though some of the same kinds of chemicals will be required as are used in producing the scheduled quantities of 100-octane aviation fuel. It seems logical to trust the petroleum engineers to produce the raw materials needed for synthetic rubber production, leaving the making of synthetics of uniformly good quality and their utilization as the matters for greatest concern. Great standardization of materials and conditions is needed before the quality of average production will be as uniform as desired.

"Most of the large rubber companies have been working with synthetics for the past few years, often more with a view to supplementing the properties of natural rubber for special services than with the present crisis in mind, and have already acquired much valuable information on the properties and processing of the new types. It has been found that synthetics in general are not as workable in the plant as is rubber, and most require liberal additions of chemicals to make them usable. These chemicals, in turn, are often of limited availability and some are wanted for other uses. Being non-rubber, they dilute the rubberiness of the whole composition. Synthetics tend to be difficult to work on rolls and in the forming and curing operations call for extra power and labor, as well as reduce plant capacity by the need of additional mixing equipment. More familiarity must be gained before these processing disadvantages can be overcome.

"For the 60 to 65 percent of rubber in a tire tread, a composition is needed that has high 'modulus,' the quality of strong resistance to deformation. High modulus is one of the factors giving resistance to wear and ability to absorb shock. Other qualities are also needed to conform to roughness of surface without undue abrasion. For tread use, some of the synthetics are satisfactory, but reclaim is less well adapted. The tread has to be bound to the carcass of the tire, and for most methods of construction an intermediate or binder strip may have to be used, rich in natural rubber, which possesses the extremely good adhesive properties that are short in most synthetics. For the carcass stock, which must adhere well to the fabric and stand flexing without getting too hot, a considerable percentage of reclaim may be used, strengthened by a moderate proportion of natural rubber. For inner tubes, the requirements are high elasticity, imperviousness to air, resistance to heat, and resistance to tear. Experience with synthetics in inner tubes is apparently still limited. For tank treads backed by metal, mixtures of reclaim and synthetic rubbers should be excellent. For airplane fuel tanks, the inner lining must be made of gasoline-resistant synthetic and the self-sealing layer must to date be made of raw natural rubber. For each service, particular ingredients serve best. Ultimately, economic considerations as well as specific utility may determine the

kinds of rubbers to be used for each specific service.

"Rubber is possibly destined to join the long list of natural materials replaceable by synthetics, starting with indigo and now including camphor, vitamins, rayons and drugs. We have yet to acquire the art of economically manufacturing tires from synthetics within the facilities of existing industry without the use of a substantial percentage of natural rubber. The ultimate goal will not be achieved by the mere expenditure of millions on plants to produce synthetic rubbers.

"The rubber situation is now serious. Many capable minds and hands, however, are working most effectively to overcome the worst features of the situation. How soon some of the new developments may be available for non-military use is still problematical. The drawing on the resources in this hemisphere for natural rubber, and the probability of an economically sound synthetic production based on petroleum raw materials, may not only solve our wartime problem but may make us virtually independent of Malaya and of the East Indies plantations in the future."

Science in The Groove

THE alphabetical conglomeration FAECT did not have its origin in Washington. It is tongue spiraling designation for the Federation of Architects, Engineers, Chemists and Technicians, a union among scientists, which proposes that it go to Washington, where an Industrial Chemical Research Board be set up to direct the technologists of the petroleum industry in efforts to win the war.

By inference it charges that men in the laboratories are wasting time and effort at diverse and unnecessary duties. What it wants is for the personnel of this branch of society to get its orders from one source. Evidently there is a belief that members of the proposed board will be better qualified to find duties than are the men who must solve the problems.

It would restrict the scientist and get rid of competition. Evidently there is faith in the proposition that the more men at work on a project, the quicker it will be solved.

It was Charles F. Kettering, who when instructed to put more men on a problem, replied:

"Two hens will not reduce the three weeks necessary for hatching eggs."

Imagine the dimunitive Steinmetz going down to Washington to get instructions. With him it was "no smoke, no Steinmetz," whereupon a wise management left him with his long cigars and a free reign as to what he attempted and how he accomplished it.

No politician would have directed Faraday to accomplish the battery. Instead a product of voting asked of the battery, "what good is it?"

"What good is any new born baby?" Faraday asked in reply. "It may grow up so you can tax it."

These are a few of the men who have worked at problems of their own choice and thereby contributed more to the welfare of mankind than all the politicians of history.

Synthetic rubber will be perfected quicker by individual effort and the competitive urge than by governmental direction. Meanwhile the seekers of rubber knowledge will by accident and design uncover countless other benefactions for mankind.

Until the scientist fails under private employment and individual initiative, harnessing him with the dictates of union regulations and political restrictions will amount to burying science in a rut.

On Its Way To the Top

HOWEVER confusing the prospect for rubber may be at the moment, there is little liklihood that the latex of the Hevea tree ever will regain its place in the world of rubber. Of necessity science has been compelled to go in competition with nature.

Since science has won other battles of this nature, why expect it to fail with rubber? A few years back rayon was an unsatisfactory substitute for silk. For a brief period nylon did not measure up to silk as a material for sheer hose. The chemist, however, stuck to his work and each came to a standard which placed silk in the secondary position.

Now the technologists of two industries, rubber and petroleum, are working under a pressure that did not drive the men who worked at rayon and nylon. These seemed possible, therefore desirable. Rubber is essential. It must be done. Abilities of the two sets of scientists are beyond question. Under these circumstances it is reasonable to expect the final product of their endeavor to push natural rubber aside.

The prospect for rubber is a better product at lower cost.

Safe Practices Are Paying Off

WHILE most industries were accumulating a higher accident record, petroleum went the other way for the first part of 1942. For the industry the record was 11 percent lower than for the corresponding period of last year. Drivers of tank trucks established a record of 23 percent reduction. In industry as a whole truck fleets had an increase of 5 percent.

Pipe-line operation, both gas and oil, came up with a 20 percent reduction in accident frequency.

Importance of Butane In This War

R. L. HUNTINGTON
University of Oklahoma

NATURAL gasoline manufacturers realize the important part which the butanes are playing in the production of materials highly essential for the winning of the war. Through thermal and catalytic conversion processes, isobutane is being made into isooctane, an invaluable blending agent for aviation motor fuel. Normal butane is being converted into butadiene through dehydrogenation. Approximately three parts of butadiene and one part of styrene make up the principal constituents going into the manufacture of artificial rubber.

1. Raw Gas Production

The butanes are present in various percentages both in the gas and crude oil which are produced from the many reservoirs in this country. Since the rate of production from a large number of the major fields is set by proration at certain allowables per well or per acre, the natural gasoline manufacturer has little control over the quantity of butanes which are produced from such reservoirs. In some fields where heat is applied to crude-oil emulsions, the use of high treating temperatures will result in an increased recovery of butanes at the expense of the crude oil itself. By far the greater portion of the available butanes is to be had in the gas streams coming from oil-gas separators in new fields, and from casinghead in old settled pumping areas. The gasoline manufacturers usually are expected to operate their plants in such a way that the best interests of the oil producers in the field are taken care of. Any other policy would be short sighted, since the two divisions must work together for the maximum overall profit, although the plant may be owned by one company and the oil and gas production by another.

2. Distillate Fields

There has been a gradual increase in natural gasoline and butane production over the past five years as the result of the development of deep reservoirs throughout Texas and Louisiana, which contain single-phase hydrocarbon mixtures under high pressure. Through multi-stage separation, a fairly high percentage of the heavier distillate fractions were recovered from these fields early in this period. Oil absorption plants operating under 1000 to 2000 pounds per square inch are rapidly taking the place of the stage-separation method of distillate recovery, because of the higher efficiencies obtainable. In these absorption plants, from 60 to 90 percent of the butanes are being recovered with 98 to almost 100 percent of the pentanes and heavier constituents. Heavy absorption oils make it possible to extract the natural gasoline under high pressure (1500 to 2000 pounds) thereby lowering the cost of recompressing the dry residue gas for reinjection into the reservoir. With stage separation the optimum pressure for distillate recovery often runs as low as 1000 pounds for mixtures having low molecular weights. A patent has been applied for by Reid[2] dealing with the use of an absorption oil in order to shift the optimum condensation pressure to a higher level.

3. Secondary Recovery Operations

Water flooding and gas recycling are the two principal methods which are being employed by the petroleum industry for boosting the production of crude oil from partially depleted fields which no longer can produce economically without some outside stimulation. From the standpoint of increased oil recovery, water flooding usually offers by far the more effective method for cleaning the reservoir of its oil content. For the gasoline manufacturer, the artificial water flood seldom helps to increase production and in fact often hastens the day of complete shut-down.

In a number of reservoirs, water flooding is passed up in favor of gas recycling. Such reservoirs may have sands which are difficult to wet with water, or the field may be located where an adequate supply of water is unavailable for flooding.

Recycling of dry gas will, as a rule, cause a decrease in gasoline content from the producing wells. However, the denuding action of the dry gas on the crude oil in the reservoir will cause larger quantities of available gasoline to be present in the produced gas. In other words, the increase in gas volume offsets by far the decrease in gasoline content of the produced gas. When, however, the content of the raw gas from certain producing wells falls below a certain economic level, those wells must be either abandoned or pinched back so that a larger share of the dry gas will go to other wells operating under lower gas/oil ratios.

4. Vacuum Operation

In many old-settled volumetric reservoirs, the gas is pulled from the casingheads under vacuum. In the Mid-Continent, such fields as Burkburnett, Burbank, and Cushing have produced oil and gas with vacuum on the casingheads for the past 10 to 25 years. Whether such a method of operation is wasteful has brought forth many arguments pro and con. Data have been published[1] which may well be used to prove both sides of the controversy to be true. It is often argued that crude oil gravities suffer as the result of vacuum maintenance. However, the records of many fields fail to show appreciable changes of gravity during the producing life of the reservoirs. No doubt much of the natural gasoline producion resulting from vacuum comes from the vaporization of crude oil in the gas cap which would otherwise never be produced. This explanation might account for the

continuation of constant crude oil gravities after vacuum is applied to a reservoir.

High Efficiency with Present Equipment

With the present shortage of equipment of all kinds as well as raw materials from which plant equipment could be fabricated, it behooves the natural gasoline manufacturer to keep his plant in A No. 1 condition. Postponement of necessary repairs may seem to result in savings for the present, but such negligence never pays dividends at the end of the year.

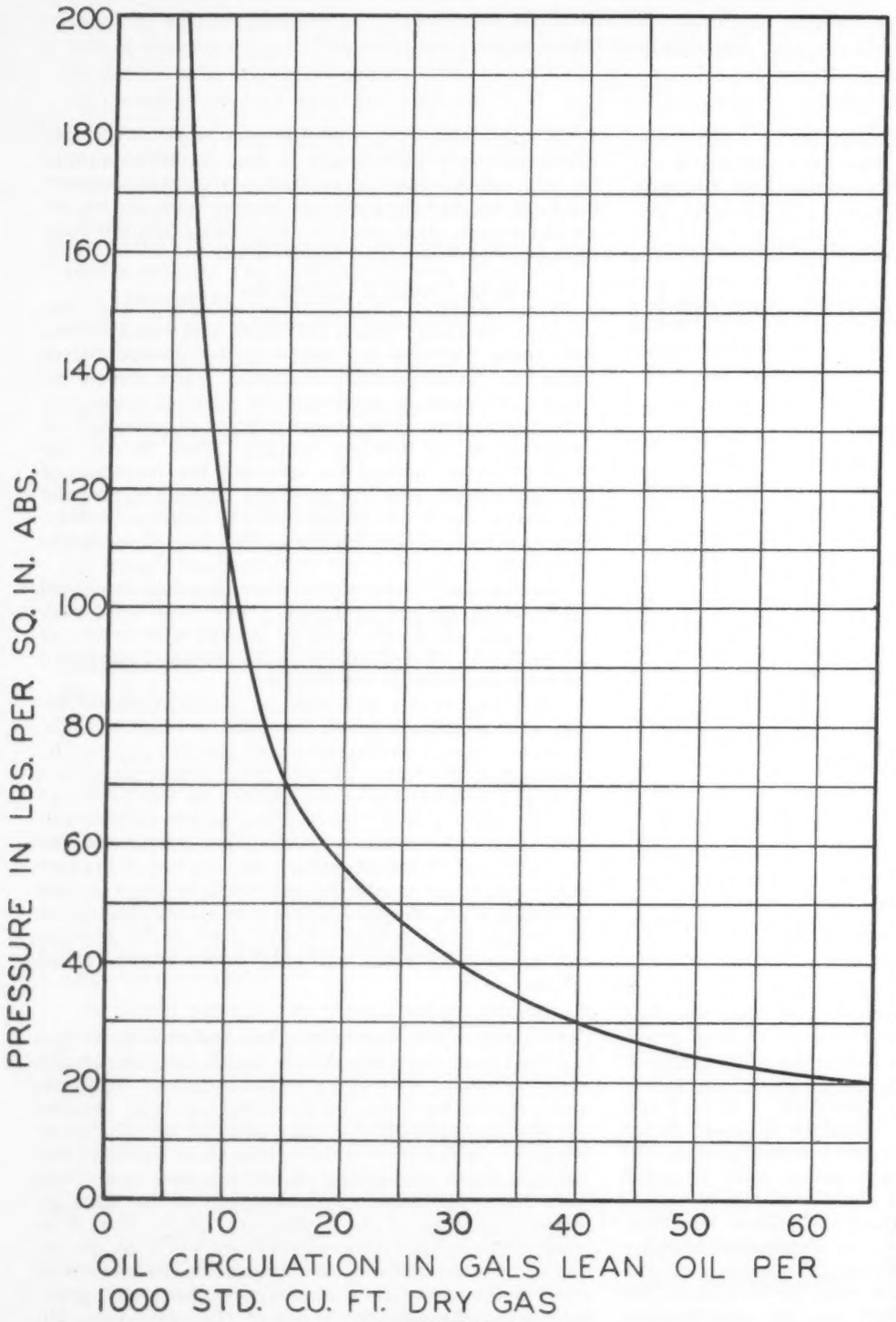


FIGURE 1
Effect of Absorption Pressure on Oil Circulation (Low pressure range below retrograde region)
Constants:
Temperature = 90°F.
Theoretical Plates = 16

1. Scale Prevention and Removal

The fouling of heat exchanger and condenser tubes due to hard scale deposits or the accumulation of sludge, is indirectly the cause for the loss of much gasoline into the plant residue gas, as well as the increase in the cost of operation. Scale on cooling coils means that the lean oil to the absorbers will not be as low in temperature as it should be in the summer time. The capacity of each gallon of absorption oil to strip the raw gas of its natural gasoline constituents practically doubles for every 35° F. decrease in temperature in the 50° to 100° F. range. This rule holds true as long as the temperature of the oil remains above its wax-forming point.

2. Importance of Clean Absorption Oil

Contamination of absorption oil usually results from the influx of crude oil mist or liquid into the plant with the raw gas. This influx causes the molecular weight of the absorption oil within the plant system to rise, thereby reducing the number of mols or pound molecular weights per 1000 gallons of oil circulated. Still more harmful to the plant is the deposition of wax in the cooler parts of the absorption system. If crude oil cannot be kept out of the plant by the installation of mist extractors on the inlet to the absorbers, it is well to have a continuous system for topping the good absorption oil under vacuum from the crude oil residuum.

From the standpoint of heat transmission, the circulation of clean oil results in the attainment of much higher heat transfer coefficients. Sludge deposition on the outside of exchanger tubes not only reduces the saving in heat to a small fraction, but it causes greater power requirements for pumping

the oil through the smaller flow channels. The presence of crude oil in the absorption oil means an increase in the viscosity and a reduction in the oil film coefficient of heat transfer.

3. Water Supply

Formation of scale is injurious to all types of equipment, and causes operation and maintenance costs to mount. Prevention of scale can be had in three ways:

1. By water treatment calling for the precipitation and removal of scale-forming chemicals before the water enters the plant system.

2. By adding a colloid which will keep the scale-forming compounds in suspension until the concentration becomes great enough to warrant a renewal of raw water within the system.

3. By use of zeolite treatment, in which hard salts are converted into non-scale-forming salts of sodium.

Each plant presents a problem of water treating in itself, the solution of which calls for the services of a competent chemical engineer. Nothing can cause a boiler or an internal combustion engine to depreciate in value faster than the operation of such equipment in a heavily scaled condition. For this very reason many plants have enclosed soft-water-circulating systems for the engine water cooling jackets.

Absorption Efficiency

1. Effect of Absorber Pressure

By increasing the pressure on the oil absorber below the retrograde range, it is possible to decrease the oil circulation required for a definite extraction of butanes and pentanes from the raw gas. Whenever the residue gas must be delivered at a high pressure for gas lift or for fuel at some distant point, the practice is to compress the gas up to the required delivery pressure before absorption takes place. If the dry gas is to be consumed in the immediate area of the gasoline plant, the absorber pressure is generally kept between 40 and 50 pounds per square inch, gauge. Although this intermediate pressure calls for more oil circulation, the added cost of this circulation does not amount to as much as the increase in gas compression cost. The relationship between absorption pressure and oil circulation is shown graphically in Figure 1.

2. Effect of Oil Temperature

Good plant operation calls for the lowest oil temperatures which can be obtained during summer. Since the cold lean oil which is pumped over the top of the absorber offers the last chance to stop the loss of gasoline into the residue gas, it is easy to see that the vapor pressure of this oil must be kept as low as possible. Several plants throughout the Mid-Continent have seen fit to refrigerate the lean absorption oil with butane or propane. Such refrigeration systems require considerable compression costs, but they do lower the investment in steam boilers, heat exchangers, and oil-circulating equipment. The

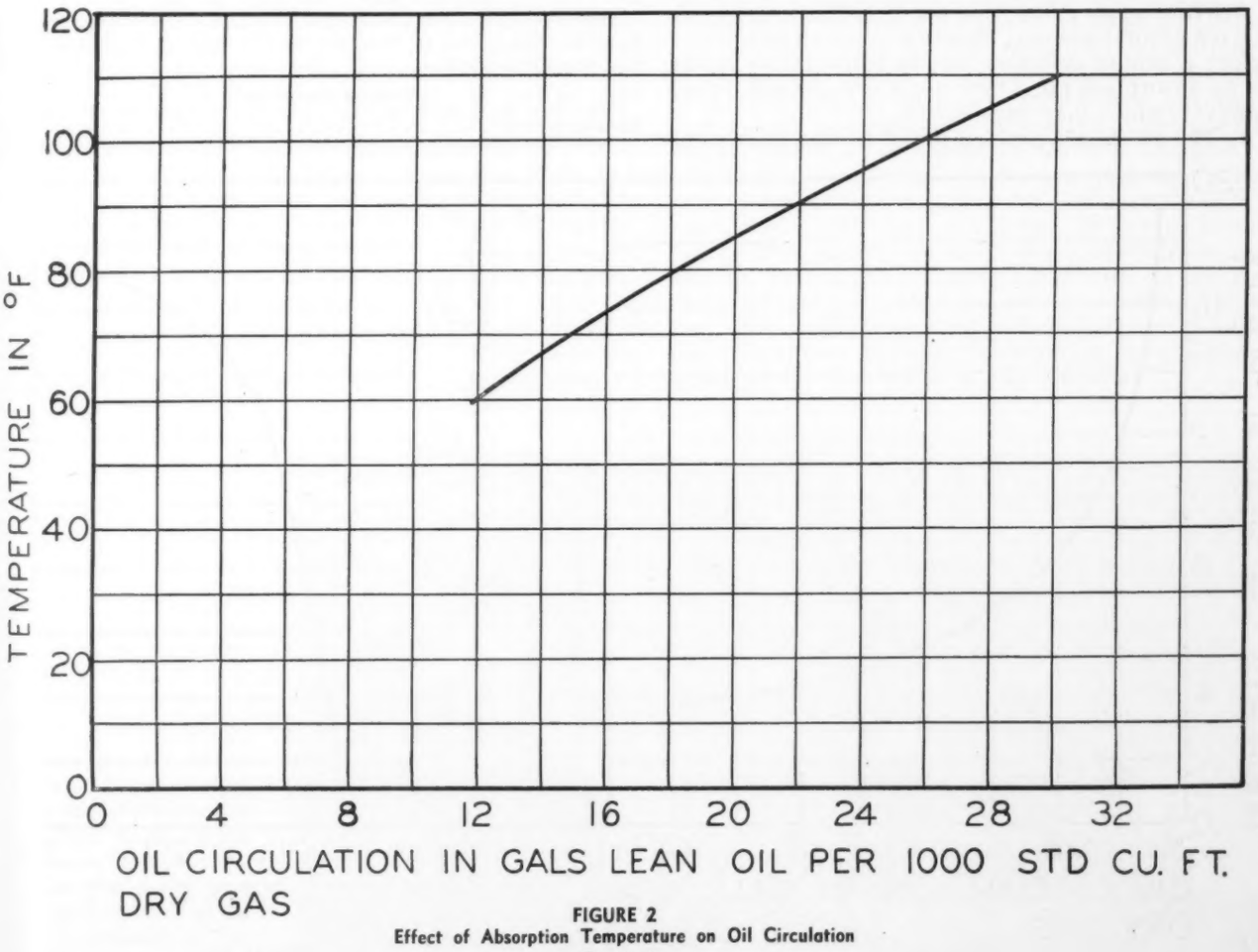


FIGURE 2
Effect of Absorption Temperature on Oil Circulation
Constants:
Pressure = 53 lb./sq. in.
Theoretical Plates = 16

effect of temperature on oil circulation is presented graphically in Figure 2 where it is seen that the oil circulation doubles between 60° and 95° F. for the same extraction efficiency.

3. Number of Theoretical Plates

By increasing the number of bubble plates in the tower, the oil circulation can be materially reduced. For example, in Figure 3A, it is seen that whereas 41 gallons of oil per thousand standard cubic feet of dry gas are required for a 4-plate tower, only 22 gallons are needed for a 16-theoretical-plate absorber. The most economical tower to build will, of course, depend upon the relative value of the gasoline to be marketed and the cost of operating the plant. Probably some intermediate point such as 8 to 12 theoretical plates may prove to be the most economical tower to select, however, the trend recently has been toward installation of more plates in each absorber. This tendency may be due to the increasing demand for propane and the butanes.

4. Percentage Normal Pentane Recovered

Many absorbers are designed on the basis of the recovery of a certain percentage of normal pentane. As higher percentages of the pentanes are desired more absorption oil must be circulated. This relationship is shown in Figure 3B. The curve brings out that as the last small percentage of normal pentane is recovered from the raw gas, the oil circulation must be increased to a great extent.

5. Selection of an Absorption Oil

Each natural-gasoline situation needs to be studied before a proper selection can be intelligently made on an absorption oil. There are a few general rules, however, which may be followed.

1. The oil should have an initial boiling point well above the end point of the raw natural gasoline, so that the oil will not distill over with the gasoline.

2. The oil should be free of heavy ends which may cause too high a pour test thereby resulting in solidification of the oil in the cooling coils.

3. Waxy hydrocarbons should be absent (or present in very small amounts). Heavy asphaltic fractions may promote the formation of emulsions which are highly undesirable.

4. The number of mols per unit of liquid volume should be a maximum. This result usually can be accomplished by selecting a low-molecular-weight oil. For example: If the absorption capacities of two oils are the same per pound molecular weight or (pound mol) which of the two following oils would be selected?

	A.P.I. Gr.	Sp. Gr.	Mol. Wt.
Oil (A)	35	.85	210
Oil (B)	40	.825	180

$$\text{Lb. Mols. per gallon of Oil (A)} = \frac{.85 \times 8.33}{210} = .0336$$

$$\text{Lb. Mols per gallon of Oil (B)} = \frac{.825 \times 8.33}{180} = .0382$$

$$\text{Relative effectiveness per gallon } \frac{B}{A} = \frac{.0382}{.0336} = 1.135$$

5. The absorption oil should be one from which the gasoline constituents can be readily denuded or stripped out in the still.

6. In high pressure absorbers operating at 600 pounds or more, higher-molecular-weight oils are recommended since there is a tendency for vaporization to take place in the retrograde region, especially for the lighter oils.

LITERATURE CITED

[1] Bureau of Mines Technical Paper, "Effect of Vacuum on Oil Production."
[2] L. S. Reid, personal communication.

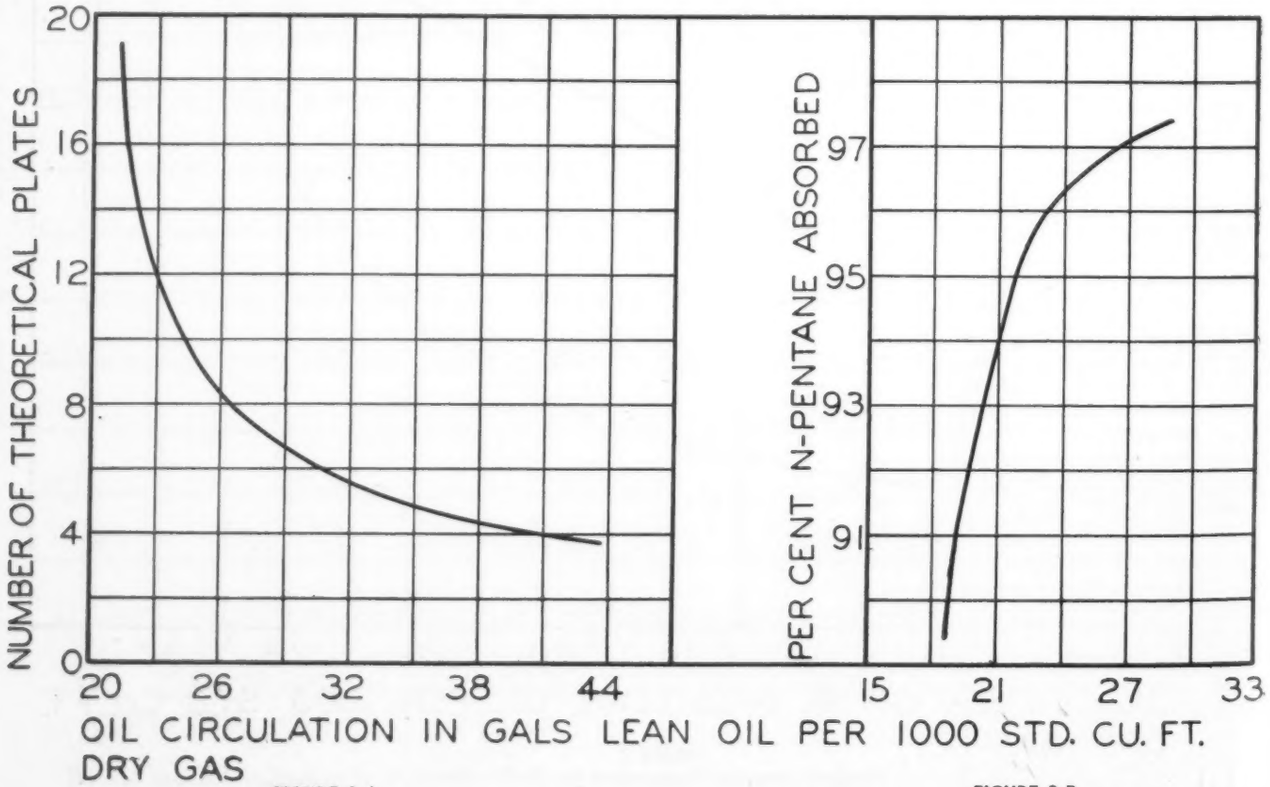


FIGURE 3-A
Effect of the Number of Theoretical Plates on Oil Circulation.

FIGURE 3-B
Effect of Percentage of Normal Pentane Absorbed on Oil Circulation.

Condensation Combined With Water Treating

BY a combination of boiler-water treatment and condensation of all exhaust steam, Continental Oil Company has brought satisfactory operating periods for boilers in its No. 1 natural gasoline plant in the K-M-A field. Without water treatment oil-field-type boilers were forced out of service as often as twice a week. Now runs of 60 days are frequent.

The system includes condensation of steam from turbines, reboilers and heaters in a special fan-cooled radiator unit. Water thus recovered is combined with raw feed, all of which is treated with chemicals.

Steam power predominates in design of the plant. Its recovery could not be accomplished without a radiator type condensing unit. Forced draft for this unit is through two fans, which are turbine-driven and the exhaust from this turbine goes into the condensate-recovery system.

Exhaust from the steam-powered and steam heating units is collected in an 8-inch line running through the main pump room and connected to a horizontal 8-inch header across the top of the tube and fin condensing sections. The other end of the exhaust steam line is connected to a pressure-operated hot well, from which an excess exhaust steam line leads to a remote part of the plant. An automatic pressure controller on this line, set to operate at 15 pounds, gauge, serves as a relief valve for the condensing system.

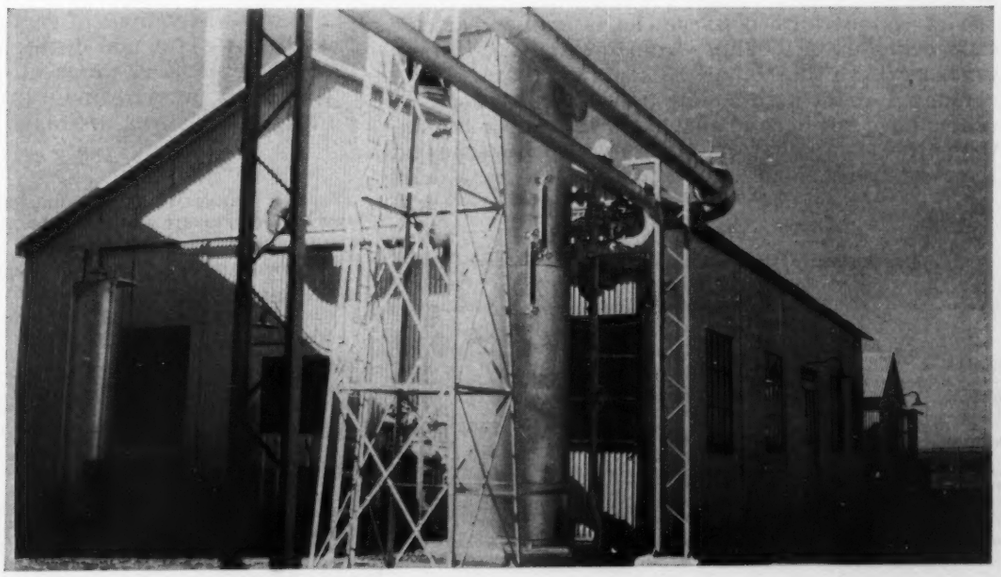
The system is maintained with an operating pressure of 10 pounds, gauge, on the hot well end of the exhaust line, and 5 pounds on the collection drum at the base of the tube and fin sections. Because of the pressure differential, a turbine-driven pump removes the condensate from the collecting drum by instrument control.

The system has capacity of 14,000 pounds of exhaust steam per hour under normal atmospheric conditions.

Behind the boiler room, the feed water is handled by reciprocating pumps, one of which feeds the raw untreated water from the 1500-barrel reserve supply tank to the vertical hot well. The quantity of raw water required for supplying the boilers is governed by the amount of condensate returned from the condensing system to the hot well. Deficiencies of feed water are made up by the raw-water pump which operates on a governor controlled by a level maintenance instrument on the side of the hot-well tank.

The chemical formulae for conditioning the water is introduced into the hot well in quantities determined by conditions in the boilers themselves. The water in the boilers is frequently checked by analyzing samples taken to determine the concentration of salts, upon which to base the quantity of chemicals necessary to maintain trouble-free operation.

A system of continuous blow-down is included in the method of boiler operation, which is obtained by attaching a quarter-inch by-pass around the normal blow-down valve assembly. An indicating valve is connected in this line which may be set to permit the desired quantity of blow down which is recommended by the plant chemist. And with all parts of the combination system in normal working condition, the steam-generating section of the gasoline plant functions without interruption, and without unnecessary supervision of the operators.



Raw water for boiler makeup is determined by the amount of condensate returned to the hotwell adjacent to the boiler house. The raw water pump is controlled by the level instrument on the side of the hot well.

Vapor-Liquid Equilibria For Hydrocarbons

C. D. SHIAH, The Tung Li Oil Works, Chungking, China

IT WAS found that if the reciprocals of temperatures at which two substances exert equal vapor-liquid equilibrium constants are plotted against one another, the points so obtained would form a straight line. Based on this fact, a chart is prepared to represent vapor-liquid equilibrium constants for all hydrocarbons at all temperatures and pressures. For compactness and ease of application this chart excels over other forms of presentation. This chart is also useful for the prediction of vapor-liquid equilibria of high-boiling hydrocarbon fractions.

THE vapor-liquid equilibrium constants of hydrocarbons, or the ratio of the mol fraction of one hydrocarbon in the gas phase to its mol fraction in a co-existing liquid phase when the two phases are at equilibrium, serves as one of the most useful tools for the solution of the complex problems frequently encountered in the production and refining of petroleum. Numerous works have been done on this subject; notably those by Lewis[9, 10], Brown[2], Lacey[15, 16, 17], Cummings[5], Sage[14], Katz[7], Kay[8], and Scheeline and Gilliland[18]. Very recently, Sage, Hicks and Lacey[15] published an excellent review on the present knowledge of this subject.

As can be shown from the phase rule, the equilibrium constant of any component is a function of all the variables which must be stipulated in order to define the state of each of the phase. Thus, the equilibrium constant of a given component is not only a function of the prevailing pressure and temperature, but also that of the nature and amount of each of the other component present. Unfortunately the present available data are insufficient to permit such a complete correlation, and whatever the expressions of equilibrium constants we have are, except for a few more extensively studied compounds, based on the simplifying assumption that it is a function of the prevailing temperature and pressure only. Both Brown's chart[2] and Sherwood's table[19] are in this respect similar. This, as was pointed out by Scheeline and Gilliland[18] would lead to serious error, especially in and near the critical region. However, for ordinary engineering purposes, these charts or tables are still of great help, provided that one makes intelligent use of them[18].

The present form of these charts is one chart for each compound.[2, 20] Thus, from methane up to octane, we have more than 10 separate charts. From octane up, as for high-boiling petroleum fractions, no charts have yet been available. In this paper the author presents a new form of plot which combines all the existing charts in one. In addition, this new chart would be useful for the prediction of vapor-liquid equilibria of high-boiling hydrocarbon fractions[1, 6]. This plot is based on existing data and charts, and as newer and better data become available it can be easily revised accordingly, without affecting its fundamental nature of simplicity.

TABLE 1

Comparison of K read from Shiah's chart and those from other sources.

Compound	Temp., °F.	Pressure Lb./sq. in.	K (From Other Sources)	Authority	K (From Shiah's Chart)	Max. Percent Deviation
Methane	60	147	6±0.2	Taylor & Parker[20]	5.4±0.2	10
Ethane	100	500	1.35±0.02	Sage, Hicks & Lacey[15]	1.3±0.02	3.7
n-Propane	150	250	1.65±0.02	Scheeline & Gilliland[18]	1.6±0.02	3.6
n-Butane	102.2	294	0.25±.005	Nederbragt[11]	0.26±.005	3.8
n-Hexane	220	1000	0.114±.005	Katz[7]	0.116±.005	1.7
n-Heptane	160	100	0.078±.002	Kay[8]	0.081±.002	3.7
n-Octane	500	100	1.83±.02	Taylor & Parker[20]	1.90±.02	3.7

Theoretical Considerations

Cox[4] has shown that the vapor pressure of a substance can be usually represented by

$$\ln P = A - \frac{AB}{T}$$

Where P = vapor pressure in atm.

T & B = temperature and normal boiling point, respectively, °K; and A varies through a relatively short range, and is a parabolic function of the reduced temperature, °R. Within a short temperature range, A can be taken as constant.

This form can be derived from an approximate integration of the Clapeyron's equation on the assumption that 1, the volume of the liquid is negligible compared with the volume of vapor, 2, that the latter follows the gas law, and 3, the latent heat is constant for the temperature range in question.

At higher pressure ranges, where perfect gas law no longer holds true, we may take

$$\ln {}^{f}P = A' - \frac{A'B}{T}$$

where ${}^{f}P$ = fugacity of the component in the liquid under its own vapor pressure at the temperature in question and A' is a constant.

According to Lewis[9], the vapor-liquid equilibrium constant is defined as

$$K = \frac{{}^{f}P}{f_n} = y/x$$

Where y, x = mol fraction of the component in vapor and liquid phases, respectively

f_n = fugacity of the component in vapor, under total pressure and temperature of the system.

$$\ln K = \ln {}^{f}P - \ln f_n = A' - \frac{A'B}{T} - \ln f_n$$

f_n is a function of ${}^{P}R$ and ${}^{T}R$.

At any definite pressure of the system, f_n is prac-

Vapor-Liquid Equilibria for Hydrocar

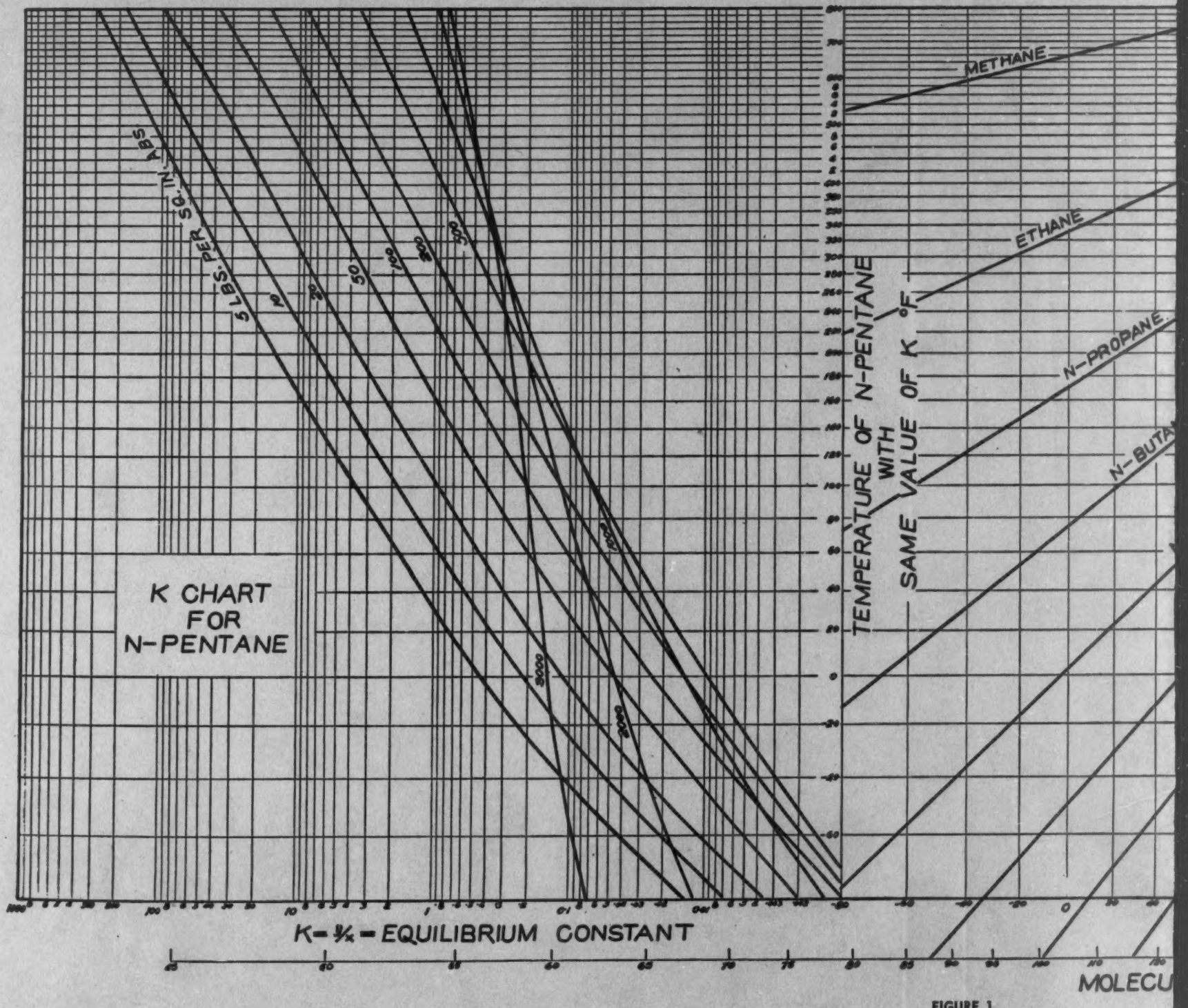
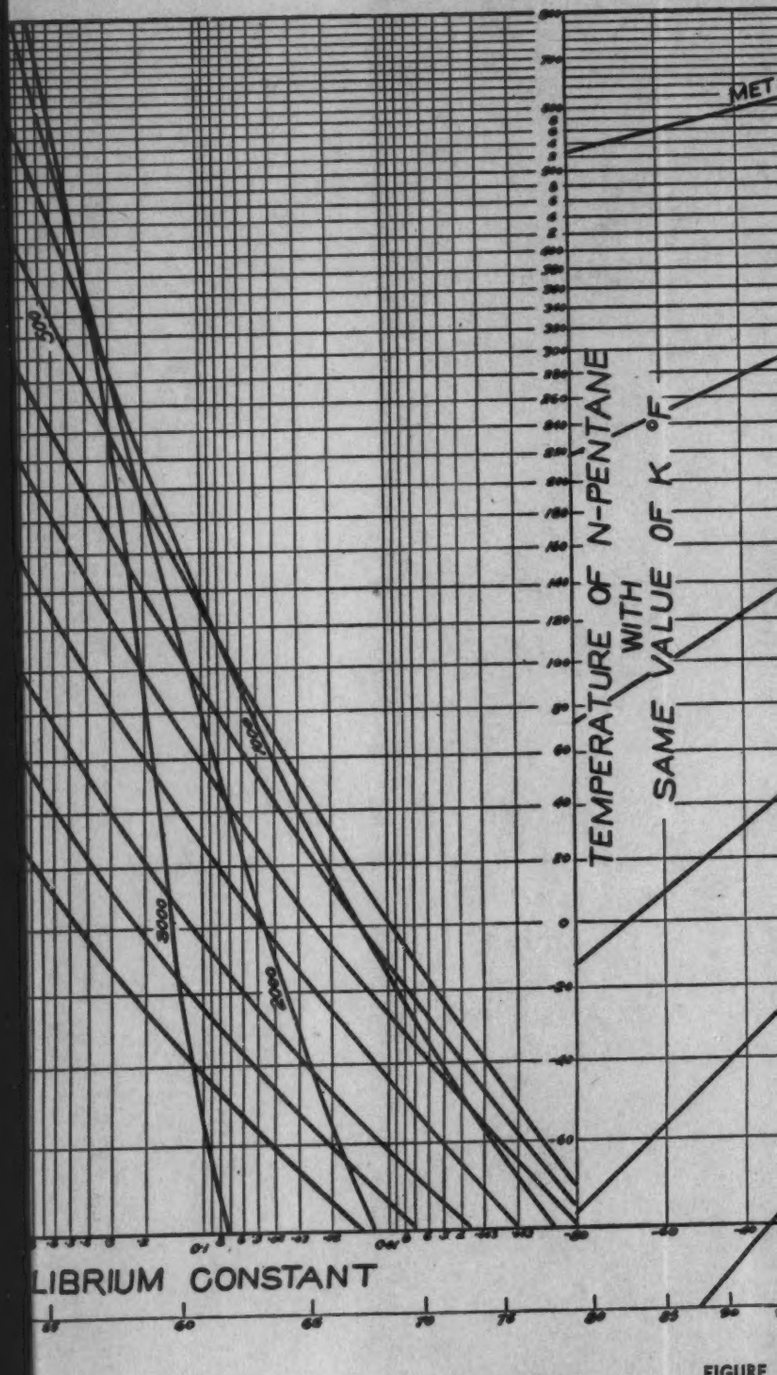


FIGURE 1

d Equilibria for Hy



FIGURE

Hydrocarbons

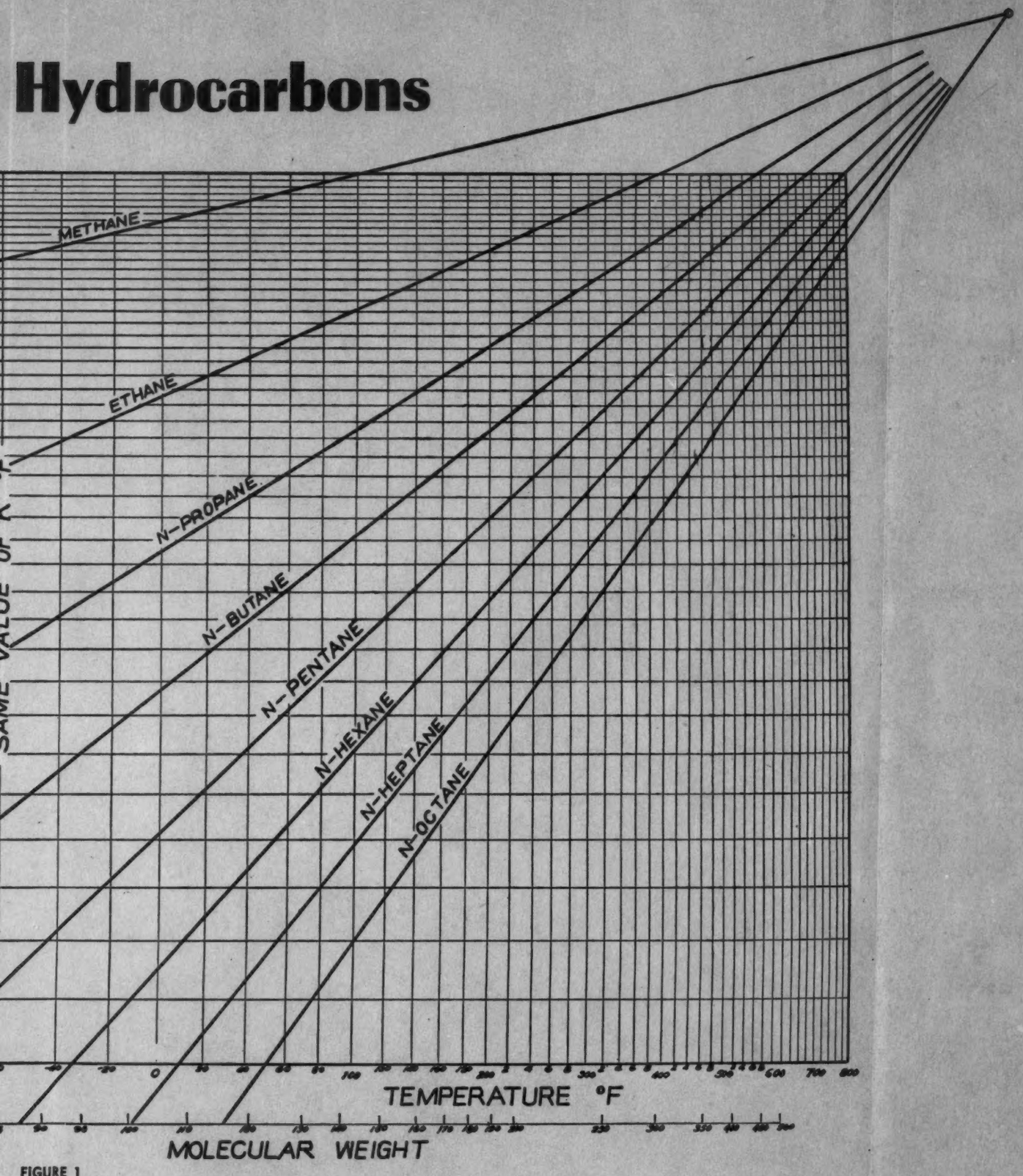


FIGURE 1

Vapor-Liquid Equilibria for H

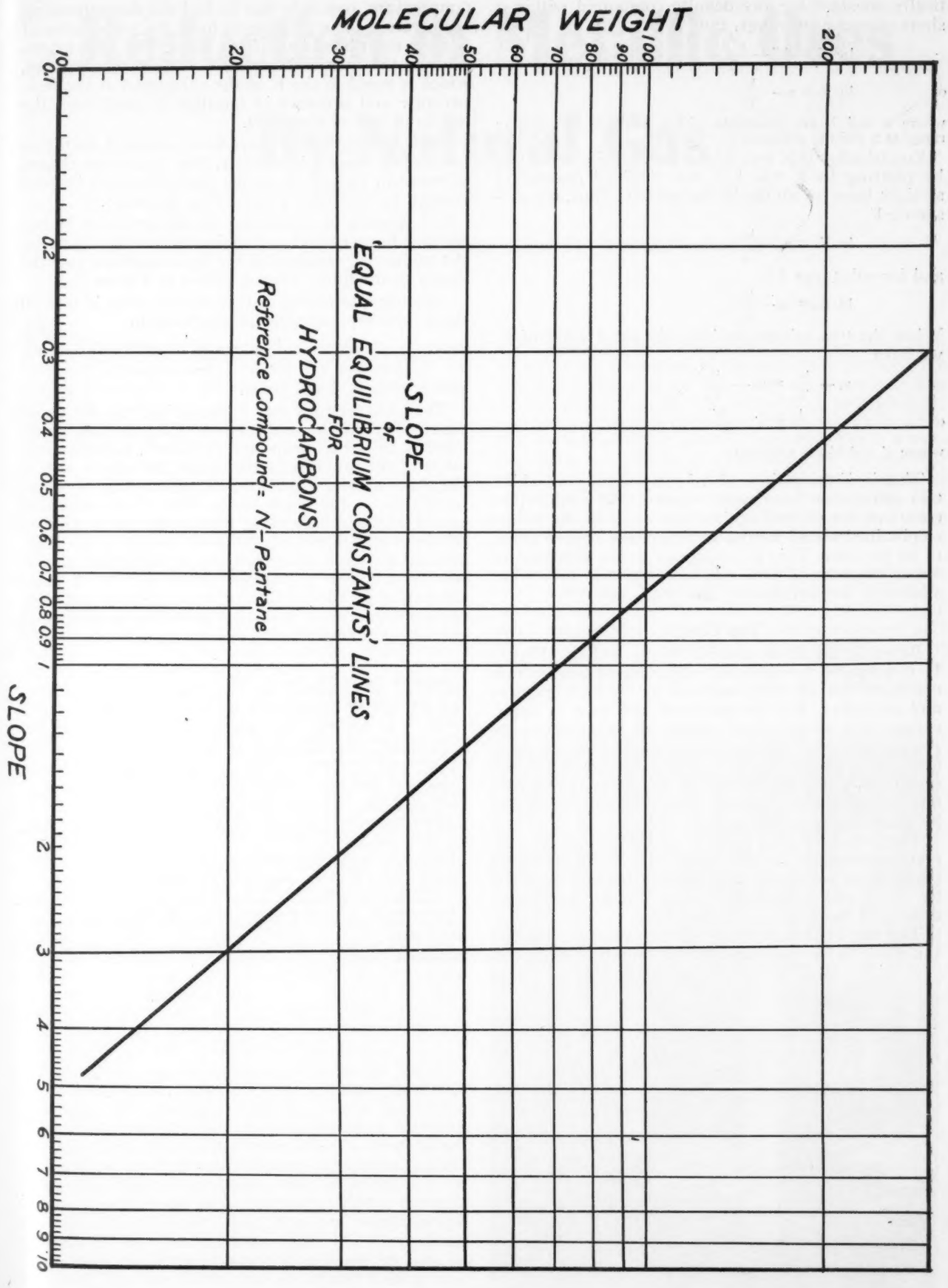

MOLECULAR WEIGHT
10
20
30
40
50
60
70
80
90
100
200
SLOPE
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
2
3
4
5
6
7
8
9
10
SLOPE OF 'EQUAL EQUILIBRIUM CONSTANTS' LINES FOR HYDROCARBONS
Reference Compound = N-Pentane

FIGURE 2

tically constant for any definite compound within a short temperature range, thus

$$\ln K = A'' - \frac{A'B}{T}$$

or

$$\ln K = a - \frac{b}{T}$$

where a and b are constants within a short temperature range at a definite pressure.

Empirically, this was found to be quite true, i.e., by plotting ln K v.s. 1/T, we obtained practically straight lines for all the hydrocarbons. Thus, for substance 1

$$\ln K_1 = a_1 - \frac{b_1}{T_1}$$

and for substance 2

$$\ln K_2 = a_2 - \frac{b_2}{T_2}$$

When the two substances have the same value of K, we have

$$a_1 - \frac{b_1}{T_1} = a_2 - \frac{b_2}{T_2}$$

or

$$\frac{1}{T_1} = a' + \frac{b'}{T_2}$$

where a′ and b′ are constants.

That is, if the reciprocals of temperatures at which two substances have equal vapor-liquid equilibrium constants are plotted against one another, the points so obtained would form a straight line. This is found to be the case. This is analogous to the relations of vapor pressure of two substances and is somewhat similar to the well known Dühring's rule.[3, 13]

The Chart

Based on the above considerations, a chart (Figure 1) is prepared to represent vapor-liquid equilibrium constants for all hydrocarbons at all temperatures and pressures. For compactness and ease of application, this single chart excels all other forms of presentation. Of course this chart can be no more accurate than the experimental data and calculated results from which it is derived, but as more accurate and complete data become available, this chart can be easily adjusted accordingly.

The reason that n-pentane is chosen as the reference compound is simply because its vapor-liquid equilibrium constants, which have been determined by Katz[7] and Cummings[5], cover a wider range and distribute more evenly on the chart.

The use of this chart is self-explanatory. To find the value of K for a certain compound at a certain temperature, one only has to find the corresponding temperature for n-pentane to have the same value of K from right hand half of the chart. The K of n-pentane at the specified pressure at this temperature, which is equal to the K of the compound at the temperature and pressure in question is read from the left hand half of the chart.

Data read from this chart was compared with that from other sources in Table 1. The figures are chosen at random. Here it is shown that this chart is good enough for ordinary engineering purposes.

It is also to be noted that for the series of hydrocarbons lines, there is a definite relationship between the molecular weights of the hydrocarbons and the slopes of the lines. This is shown in Figure 2.

Another interesting feature of this chart is that all these lines representing the relationship

$$\frac{1}{T_1} = a' + \frac{b'}{T_2}$$

converge to a single point.

Thus, the line for any hydrocarbon can be easily constructed. If the molecular weight, directly or indirectly from the mean boiling point[12], is known, the slope of the line can be read from the above plot. If the slope of, and a point on, the line are fixed, it can be drawn on the chart easily. Thus this chart also serves as an approximate means for the evaluation of the vapor-liquid equilibrium constants of high-molecular-weight hydrocarbons, or high-boiling narrow fractions of petroleum.[6] This will be of great assistance to the design of vaporization and condensation processes involving those fractions such as gas oil cuts or lubricating oil cuts, etc.

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Reduction of Metallic Ores By Natural Gas

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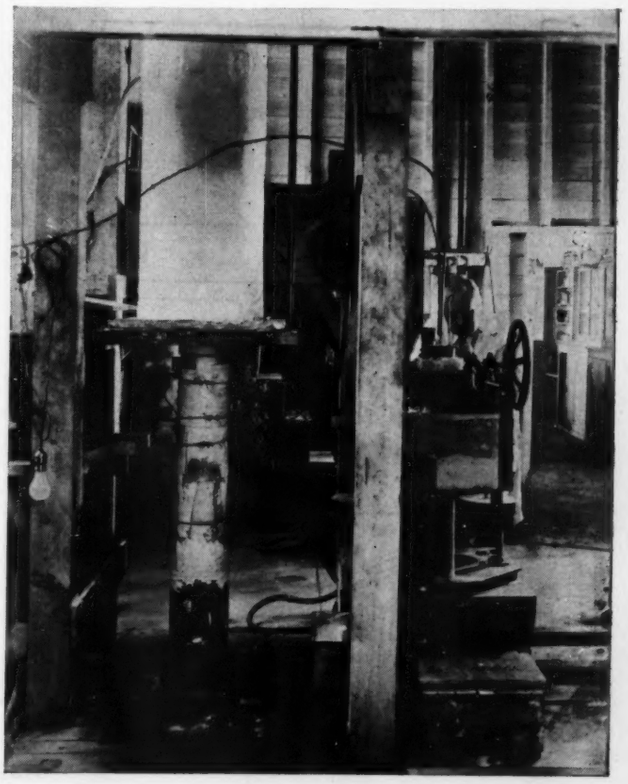
REDUCTION of metallic ores, especially iron ore, is being accomplished in localities favored by desirable proximity to the required raw materials such as coking coal, limestone, ores and favorable location relative to transportation. The Pacific Coast states have high-grade iron ores, but in the absence of coal of coking quality this operation has not become practical. Announcement of the "Clarkiron Process, developed by Walter Gordon Clark of Los Angeles, comes at a time in which the expansion and separation of the metallurgical industry is highly desirable. The process consists of the reduction of metallic ores, in relatively finely divided form, by natural gas. This process has successfully passed the pilot-plant stage and is available to reduce iron, chrome, nickel, vanadium, and titanium on a commercial basis. This process promotes reduction of ores in localities heretofore ruled out due to the absence of coking coal and encourages the development of industry where large deposits of natural gas and the desired grade of ores are available.

For a description of the apparatus and method of operation, reference is made to Figure 1. The ore to be processed is crushed and screened and delivered to the plant at (A). The ore may be crushed so that it passes a ½-inch mesh and is retained on a 10-mesh screen, or it may pass a ¼-inch mesh and be retained on a 20-mesh sieve. This suggests that finely divided ores heretofore not economically processed may be handled by this process. By means of a scroll feeder (B) the ore is transferred to roaster (C) heated by natural gas, in addition to hot gases from the reducing apparatus at (D). The roaster raises the temperature of the ore to about 1500° F., removing all water of crystallization. The dry ore is then moved by a feeder (E) to the bottom of the reduction tube where it is picked up by an elevator (F) and delivered to the top of the reduction stack.

The top of the reduction stack is about 115 feet above ground and provided with standard blast furnace traps (6) through which the ore is fed to the stack, eliminating loss of gas. Connected at (H) and suitably driven is a hollow shaft which extends down through the heating and reducing apparatus. In addition this shaft is provided with a spiral (J) by means of which the ore's movement down through the stacks may be controlled, however, recent developments in this process apparently will depend entirely upon the force of gravity to move the ore in the stack. The ore, in the absence of any fluxing material, passes down through a restricted area in the reduction zone. At the top of the stack the incoming ore is separated from the excess hydrogen, inerts and water vapor generated in the reduction process, the gases are removed at (L), and conducted to the roaster where they may be mixed with additional air and gas for heating purposes. These exit gases from the stack in addition may be transferred to a waste-heat boiler and finally to a condenser for the removal of water vapor, leaving the residual hydrogen to be stored and then returned to the circuit of the first reduction stack or a second reduction stack, Figure 2, in which carbon-free reduction in pure hydrogen is attained.

As the ore passes down through the reduction stack it meets the upward moving gases, hydrogen, methane and water vapor. Below the first 25 feet of stack the diameter of the outer tube is increased and the diameter of the inner tube is decreased, the ore passing between these two tubes. This change in dimensions assists the ore in the downward move-



Pilot Plant

ment and provides space for accumulating the carbon from the cracked gas and the additional space required by the increased volume resulting from the oxidation of methane. The oxides at the top of the stack are poor conductors of heat and with high electrical resistance at this point they are chiefly heated by radiation and conduction from the metallic surface of the inner and outer tubes and by convected heat from the ascending gases. One of the three movable induction coils is shown at (K), each coil raising the temperature of the ore about 100° F. The action of the induction coils is entirely magnetic, the inner and outer tubes acting as closed circuits generating heat. The reducing action starts in the field of the first coil (K) and by the time the ore reaches the middle of the second coil the temperature at which the ore tends to stick is passed and each particle now has a metallic surface. At this point, each downward moving particle in the magnetic field becomes an independent secondary and is heated independently.

The hydrogen from the natural gas being cracked at the base of the reduction stack, reduces the downward moving iron ore. In this reduction the operation may be divided into three stages. In the first stage, in the upper portion of the stack, the surface of the oxides are converted into the various intermediate oxides. The second stage, with an increase in temperature, conditions are such that the interior of the particles are reduced slowly, eliminating the possibility of rapid reduction with the formation of molten conditions and clogging of the apparatus. In the third and final stage, higher temperatures are used and with the metallized coating now on the particles, the rapid boost in temperature insures complete reduction of each particle of ore. These stages may be accurately controlled by satisfactory plant operation.

As previously stated, hydrogen for the reduction, is obtained by introducing natural gas at the base of the reduction stack. As the gas rises it comes into contact with freshly reduced hot ore and is cracked into hydrogen and carbon so completely that only about ½ percent or less of methane is left as a residue. The carbon which separates from the gas, deposits upon the particles of ore in the form of carbon black, but since the reduced metal is well below the melting point, little or no carbon reacts with the metal.

The lower section of the reduction stack is provided with an airtight cooling chamber, water jacketed, through which cooling water is circulated. Additional cooling of the discharging iron is effected by introducing the natural gas, under pressure with the resulting cooling effect upon expansion (50 pounds/square inch to 2 pounds/square inch). The iron is discharged through a water seal directly to a chain belt elevator operating in the water column which lifts it to the top of the balancing water column, where it is discharged into a rotating washer then to storage or melting equipment. The balancing water column together with a suitable water storage tank operates in such fashion as to keep water from entering the hot portion of the reduction stack with changing pressures in the operation.

The reduced ore covered with carbon, in the absence of a washer, may be removed by a spiral feed-

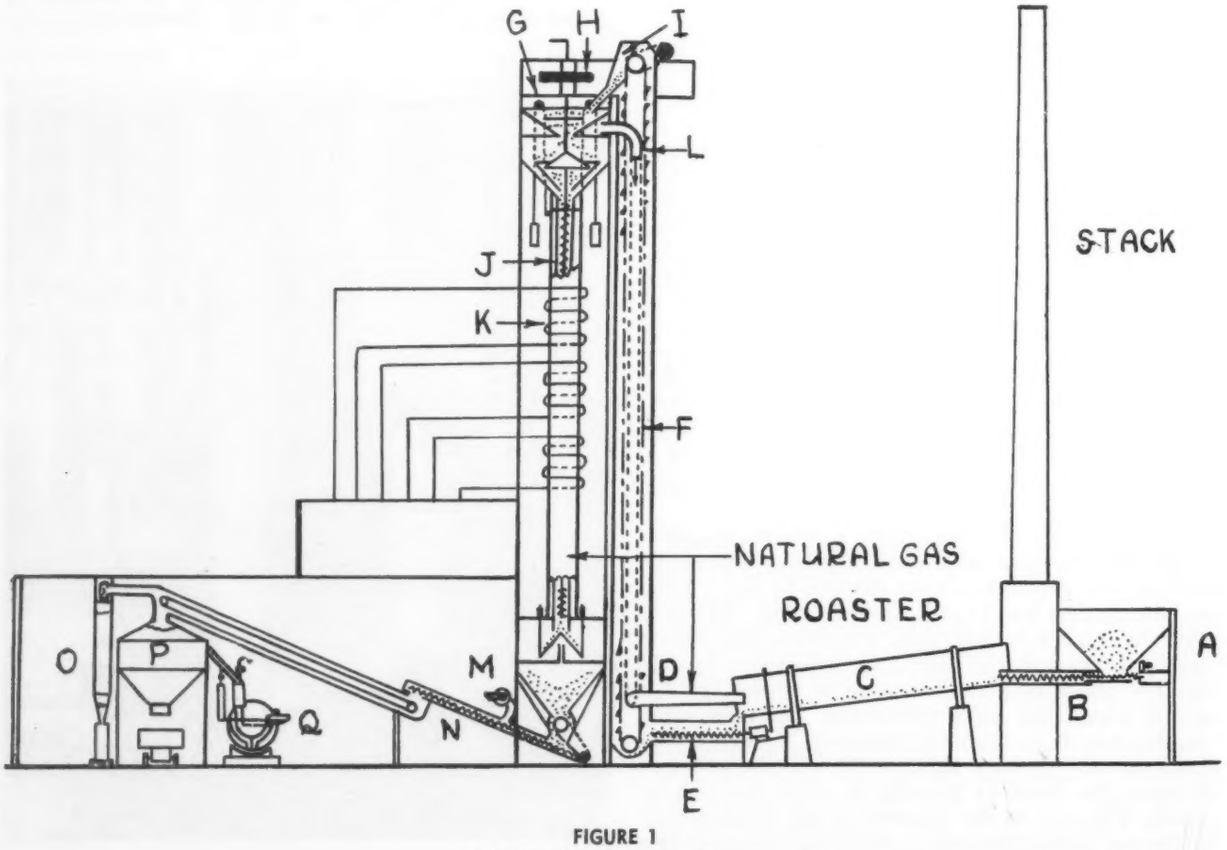


FIGURE 1
Clarkiron Ore Reduction Process

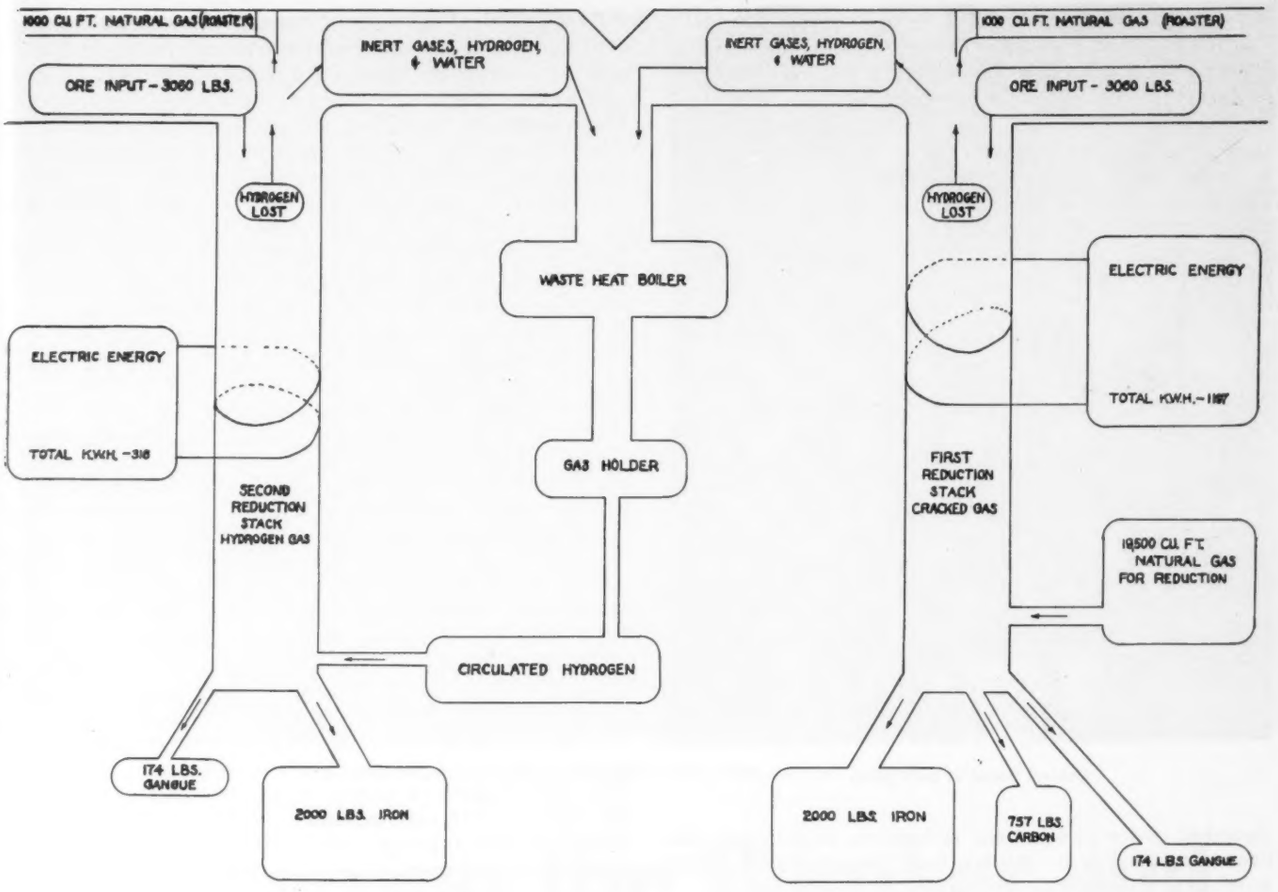


FIGURE 2

Material and energy flow diagram, quantities per short ton of reduced iron per tube when operating at 30 tons per day, per tube.

er (N) and transferred to a continuous conveyor within a housing. A blower (M) supplies air which when discharged in a cyclone bag collector (O) makes possible the separation of the carbon from the ore which is deposited at (P) or run to the electric furnace at (Q) where it may be reduced to liquid form and then cast.

The electric furnace at (Q) was designed in order that the low carbon content iron could be satisfactorily processed and cast directly into ingot or molds. This furnace is of an induction type with no electrodes thereby not increasing the carbon content of the iron. By this method the iron can be separated from the gangue or slag which is drawn off the molten iron through a slag spout.

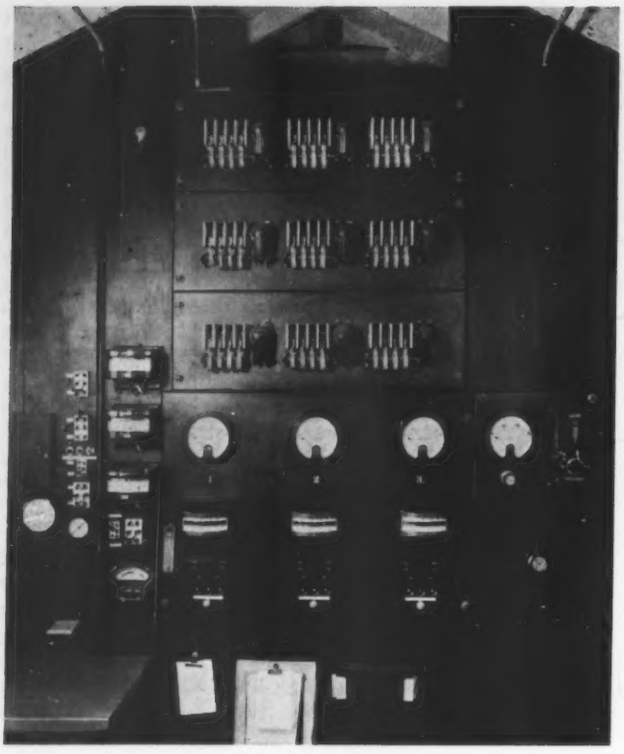
As previously stated the by-product carbon is collected in the cyclone base collector at (O) or separated from the iron in the washer, in addition some carbon leaves with the gas at the top of the reduction stack and this entrained carbon is removed by a multicone collector before the water vapor is condensed, in the case where the hydrogen is to be stored and recycled to the reduction stack. The carbon collected varies from a soft lamp black to hard carbon. The hard carbon is saleable as a color for concrete. The softer grades are used as a filter material and in the rubber and chemical industries. It is reported that this by-product brings 1 to 2 cents per pound for the coarse fractions and up to 10 cents or more for the light fractions.

Under operating conditions 37% excess hydrogen is required in the reduction stock to insure satisfactory reduction. In the reduction of Southern California hematite and magnetic ores ⅛- to ½-inch size, 3½ hours is required at 1800° F. However, in order to reduce dense magnitite and mill scale, 4½ hours is specified as the necessary time for 100 percent reduction with maximum temperature of 1850° F. This process has successfully reduced all iron ores tested, Table 1, within this time and temperature limit, with the exception of those carrying commercial percentages of manganese and silica gangue content. Chromium concentrates, in porous carbon-free briquettes, carrying 30 percent to 50 percent iron ore reduced in the time of that required for manganese, but a small amount of alkali vapor must be intro-

TABLE 1

Analysis of Reduced Ore by the Clarkiron Process

	Run No. 1 Reduction Time—3 Hours	Run No. 2 Reduction Time—4 Hours
Iron Total	70.61%	70.85%
Iron Reduced	68.10%	68.52%
Iron Unreduced	2.51%	2.33%
Titanium Total	17.10%	14.24%
Titanium Reduced	13.06%	12.06%
Titanium Unreduced	4.04%	2.18%
Manganese Total	2.20%	1.08%
Manganese Reduced	1.45%	.72%
Manganese Unreduced	.75%	.36%
Chromium Total	1.96%	.58%
Chromium Reduced	1.02%	.41%
Chromium Unreduced	.94%	.17%



Control board in pilot plant

duced in order to start the reduction. In all cases the ores should be so mixed that the reduced metal would be about 50 percent iron.

In a second reduction stack, Figure 2, ore can be reduced to iron carrying as low as 2/1000 of 1 percent carbon. This is attained in an atmosphere of hydrogen accumulated from the operation in the first reduction stack which operates in a reducing atmosphere of cracked natural gas.

The practical method of completely cracking natural gas in the presence of freshly reduced iron is of special interest in that heretofore exceedingly high temperatures were required to decompose hydrocarbons such as methane, ethane and the aromatics. This method of completely cracking methane is of great importance in this process, however, it was reported that the reduced iron on being exposed to air for a period of time does not show the same catalytic effect as that obtained in the reduction stack.

From estimates to date, this process may operate on an investment per ton of output, substantially less than that required per ton of pig iron. Plants may be constructed and operated economically on a capacity of 100 tons per day or less. The power required for a 60-ton plant per day would be 400 k.w. and for two stacks of 125 tons each per day, 1800 k.w. The frequency would be about 960 or between 800 and 1000 alternations per second. The electrical demand for the induction furnace, for metal melting would be from 600 to 650 k.w.h. per ton. Compared to the blast-furnace method, the man hours required per ton of reduced iron, delivered, under the Clarkiron Process is approximately one fifth of that required for commercial pig-iron production per ton.

The Clarkiron Process for reducing metallic oxides in natural gas appears to be a valuable addition to metallurgical operations and if developed upon a commercial scale will make available large quantities of iron, free from excess carbon, silica and sulphur. The high degree of purity in the product eliminates the open hearth or Bessemer method of purification and this fact together with other developments in this process should make available a finished steel product at a cost well below the present cost of steel production.

Acknowledgment

The writer wishes to make acknowledgment to Mr. Walter Gordon Clark for supplying the necessary information contained in this article.

Boundary lights surrounding a gasoline plant, photographed from 400 yards

Deceiving the Bomber and Anticipating the Saboteur

FORESTALLING the damage of aerial bombs and destruction by saboteurs is now a part of the operating routine in natural-gasoline plants on the West Coast. Deception through camouflage painting and complete blackout are the hindrance to bombing. Special lighting, adequate fencing and alertness of the operating personnel are the counteracting measures used in anticipation of wilful damage. Along with these are emergency methods of shutting down operations, diverting gas into the air or into other plant lines, and protecting plant forces.

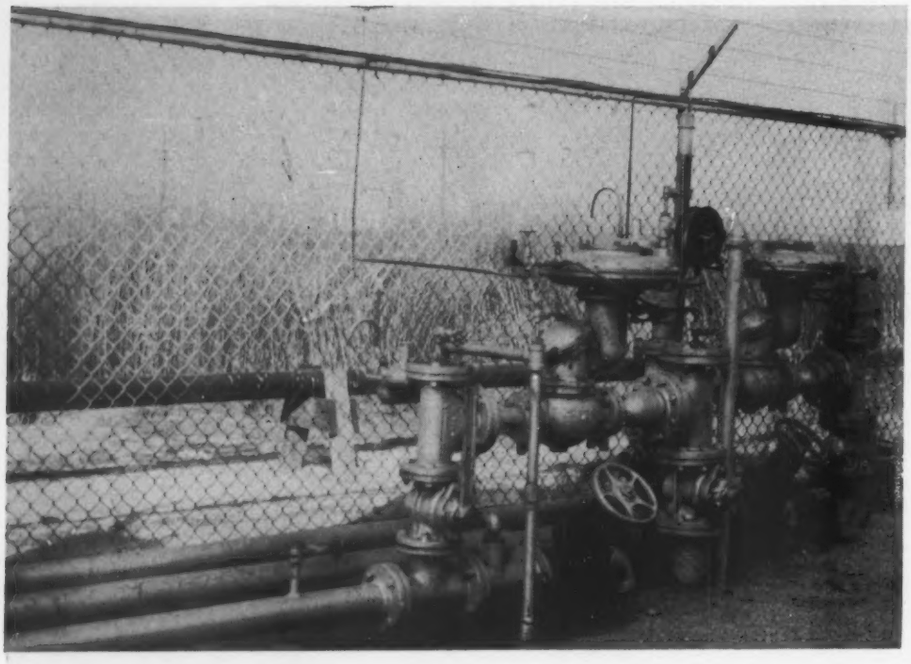
Protection against bombing may be obtained to a degree with camouflage painting and colors containing pigments which cause the painted objects to blend into the color of the soil and adjacent scenery. Many storage tanks, processing columns and vessels which recently glistened with bright colors are now toned down to the olive drab of the Army. Paints are now being compounded, containing special ingredients that prevent photographing with infra-red film, so that pictures taken from reconnaissance planes will not show the location of important installations.

In localities which have organized systems of raid information and adequate warnings, the sequence of the three principal alarms will provide sufficient time to extinguish all lights and black out the plant. Lights of some sort are almost essential for operating the machinery, and in some plants the lighting circuits are being rearranged so that the master switches will cut off all but three or four outlets. These in turn are fitted with special blackout hoods which prevent illumination from being detected outside the building and concentrate the beams to a very narrow circle on the floor.

For Limited Lighting

To prepare a black-out hood which confines the illuminated area to a circle not larger than three or four feet, a long cylinder of heavy kraft paper can be made at little expense. Assuming that the fixture has a conduit drop of 30 inches from the clamp on the roof trusses, the sheet of paper should be about 36 inches wide, so that, when formed into a cylinder it will be not less than 30 inches long. The lower end of the paper cylinder is stitched and reinforced with a heavy wire shaped into a ring as it is laced in and out of the paper near the lower edge. The side seam is closed so that light from the globe will be prevented from shining through a crack, or the seam may be closed with a coating of glue.

The cylinder is slipped up over the reflector and should fit closely, yet not so tight that it will bind when released. The top of the cylinder, just above



Fuel regulators for boilers and stills are grouped, so these units can be shut down from either the office or the gate.

Plant can be shut down from several points. Here the control is at a gate.

the reflector, is gathered loosely and reinforced with a small ring of heavy wire to hold the cylinder on the top of the reflector. A wire bail is hooked into the top stiffening ring to the top of which is tied a heavy cord. This cord is run through a pulley attached to the roof above the cylinder. The cord is brought down to the wall and attached with a quickly disconnected loop so that the cylinder can be dropped quickly. If the candle power of the lamp bulb is so great that the light shows through the paper, black paint on the inside will remedy the difficulty.

Painting Procedure

Painting of buildings is generally done with alternate irregular bands of black and white, some at an angle to the length of the building and some at right angles, but no two adjoining bands of color have the same general outline. The finished building has the appearance of an amateur paint job, but the colors blend well with any surroundings and are not visible as a detached object from a high altitude. The olive drab paint, while visible in daylight for a considerable distance is almost invisible at night and early evening.

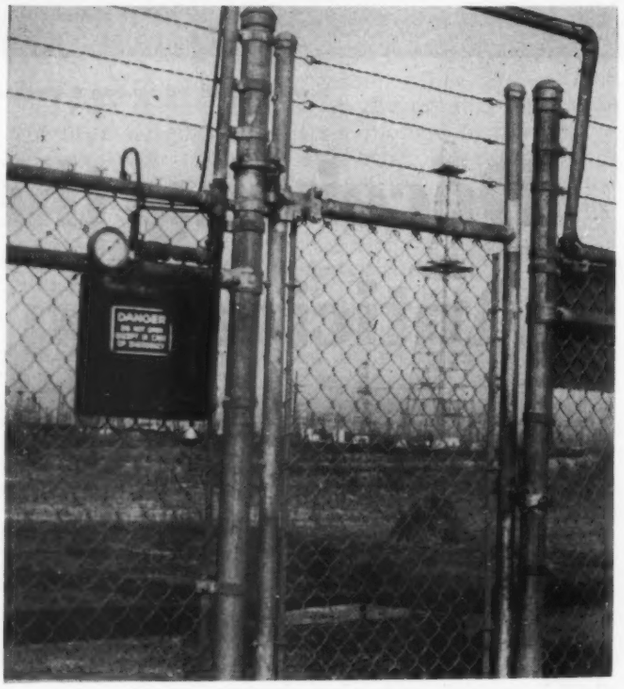
Most plants now have the window panes blacked out with paint applied on the outside, rather than on the inside of the glass. Inside painting, while preventing transmission of light from within, will reflect beams of lights coming from great distances.

One Way Gates

Some plants in congested districts where streets are near the boundary fence have been still further protected by sheathing up the inside of the entire sash with composition wall board.

Plants which are fenced sometimes are equipped with gate-locking devices that can be opened only from the inside.

This fastener employs a simple latch where a horizontal bar riveted at one end engages with a hook at the other, similar to an old fashioned door latch except there is no lifting device extending through the retaining plate. The hood covering the latch which prevents anyone from opening the gate from the outside is made of an eight-inch pipe nipple about ten inches long split diagonally. The cut is started in the center where the nipple joins the latch plate and bears off at an angle, leaving the narrow end on the gate side so that the arc described by the gate when swinging open will not be obstructed by one part striking the other. A circular plate is welded to both the gate and gate post for attaching the latch, cut down the center on a vertical line, which leaves the horizontal bar attached to the post section on one side, and the engaging hook attached to the half welded to the gate. The wide section of the hood is then welded to the half of the plate on the post side, and the narrow section to the half-plate on the gate. The hood extending inward from the post and gate when it is closed is effective in preventing a person



from extending an arm between the gate frame and post to reach the latch for unlocking.

Bomb Shelters

As a protection for workers in case of an air raid shelters are constructed ranging from simple half-dugouts with concrete walls and roof to elaborate buildings above ground. A small shelter effective for the protection of a small force can be made by making an excavation in the least dangerous part of the plant area. Digging approximately three feet, the walls are left smooth for the structure which is finished about eight by ten feet and slightly over six feet inside height. Form lumber is placed around the excavation, fashioned so that one side and both ends are closed, leaving the entrance as a small rectangle about three feet square at one end on the broken side. Steps lead down to the floor and a safety wall divides the stairway from the room beneath. The walls may be made to any desired thickness and reinforced with deformed junk sucker rods to increase the resistance to damage from shock. Form lumber is placed inside the room so that the walls and roof can be poured as an unbroken monolith. Ventilation is obtained by placing small pipe nipples through the wall forms at a height above a man's head when sitting down inside the shelter. Benches placed on either wall force men to rest facing each other to prevent involuntary crowding.

For area lighting supplementing flood lights inside the fence, boundary lights are being installed which provide a band of illumination outside the property.

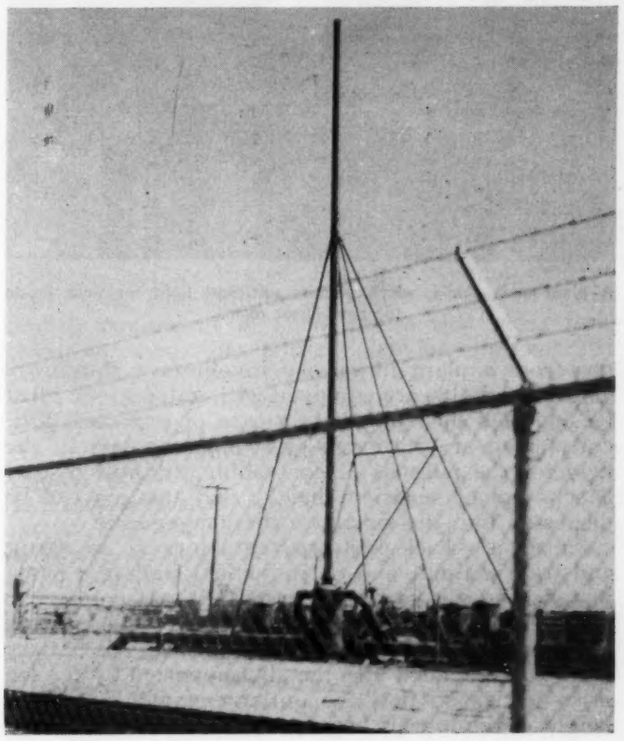
The general plan for boundary lighting is to set posts long enough for mounting the lights from 12 to 15 feet above ground and either at, or inside the plant fence. From 8 to 12 feet inside the fence provides sufficient illumination at the fence so that a person attempting to climb can be seen. On the other hand, if the posts are set outside the area boundary, a person might pass through the lighted area and arrive at the fence before being apprehended. The lamp posts are normally set on a linear spacing of from 100 to 150 feet, depending upon the type of lamp.

The result desired is an unbroken light band outside the fence and extending for a maximum visibility of 150 to 300 feet beyond the property line.

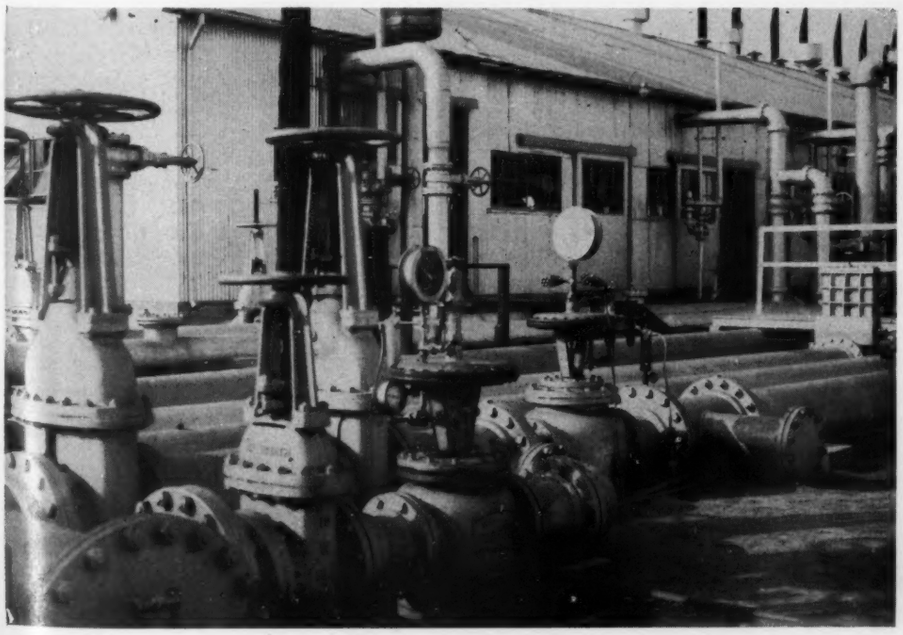
Persons attempting to approach the plant through the band of illumination can see nothing but light, while those inside the plant can spot any moving object as it enters the lighted area. When the plant is being operated with no yard floodlights, and only the necessary drops and small spots for immediate local illumination, the appearance is that of a black plot of ground containing nothing but irregular buildings.

Gathering System

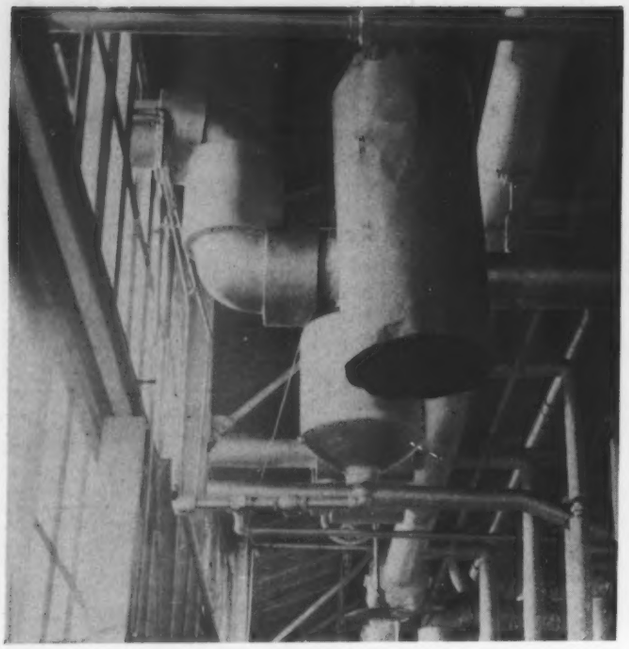
For the protection of the field and the disposition of gas, many plants have looped individual gathering systems with adjacent lines, equipping junction points with manifolds and vent stacks to divert the



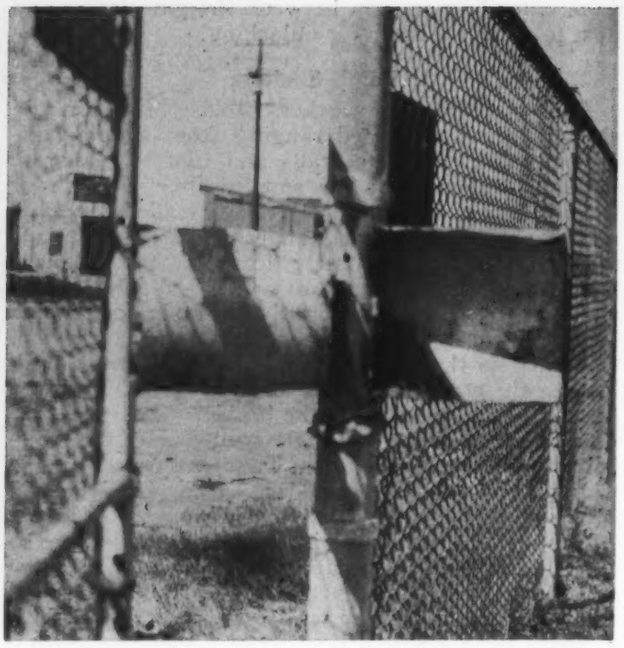
In case field gas is shut off the discharge can be through a stack and to the air or into lines of other operators.



Regulators for controlling the gas supply to the processing units divert their load to stack in emergency shut off.



A plant-made shield, which permits sufficient light for work inside the compressor room.

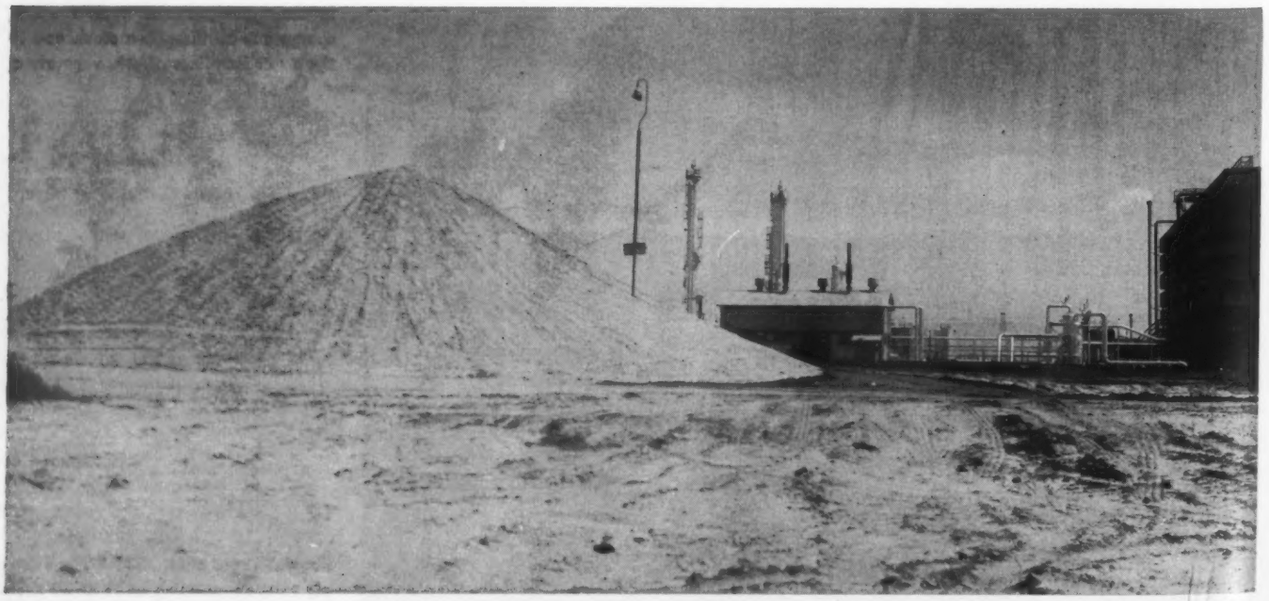


One gate is so fixed that it can be left unlocked for quick exit of the plant force but cannot be opened from the outside.

gas from a plant in case of involuntary shutdown. These manifolds are equipped with gates which must be operated by hand, but in case of expected difficulty, men are stationed at strategic points in the field for the purpose of controlling the flow of gas. Stacks are of sufficient height that the gas can be dispersed into the air above the danger zone.

Automatic back-pressure regulators at separator and trap settings, and on individual wells are being installed so gas can be released without damage to equipment. The vent stacks which formerly were short pipes rising from the ground near the battery are being extended into the air, supported by the leg of a derrick so that the outlet end will be at the height of the fourble board, or higher.

Pressure controllers inside the plant are many and varied as to their design and application. Some operators have arranged pressure controllers in sequence, and on various pressure lines so that the gas will be diverted and by-passed from one unit to the next, or passed to vent stacks automatically. Some installations are made which will shut down the plant quickly by diverting fuel gas from the units when control gates are operated from one of many stations in the plant yard and at outlet gates in the fence. These installations will by-pass gas from the entire plant to large stacks and prevent gas from the gathering line to pass with a pressure above the predetermined pressure when they begin to function.



A mound or of sand protects the Christmas tree of a flowing well

Butane Requirements Demand Efficient Extraction

ROY W. MACHIN, Superintendent
The Hamman Corporation

WITH the expansion of plants for the production of synthetic rubber ingredients from petroleum and the continuous trend of reformation of butanes into aviation fuels by alkylation, polymerization or other processes, plus diversion of butanes, especially isobutane into other essential defense specialty products, increased efficiency is demanded in the recovery of butanes.

Manufacture of natural gasoline by the absorption method is accomplished by three distinct steps. In the absorption plant the rich gas is contacted with oil in absorbers to remove the constituents desired in the finished products. After the oil has absorbed these constituents, the rich oil is passed successively through vent tanks, heat exchangers, and preheaters to the distillation unit where by a process of distillation the absorbed constituents are driven off by heat under pressure. The absorption oil is cooled by heat exchange and coolers to be recycled through the absorbers while the light constituents absorbed from the gas are liquefied by cooling and accumulated in tanks.

From there, the condensate is pumped to stabilizers where the constituents are broken up into as many various products as the plant is equipped to segregate. The three units that make up the absorption plant are: 1. the absorption unit; 2. the distillation unit; and 3. the stabilization unit. In conjunction with these three units will be found such auxiliary units as the cooling tower and boiler house.

This extraction is essentially an equilibrium phenomenon. In the absorption process there will be a portion of each component in the rich gas that enters the oil. The amount of entrance by the individual components will depend on that component's partial pressure in the gas and its vapor pressure at the temperature at which absorption is taking place. Absorption will cease when the partial pressure of the component in the oil is equal to the partial pressure of that component in the gas. In other words, no absorption can occur unless the vapor pressure of the component in the oil is less than the partial pressure of the component in the gas. If the partial pressure of the constituent in the gas is considered as the driving force that is tending toward forcing that constituent into the oil and the vapor pressure of the component already absorbed by the oil as the escaping tendency, or that force causing the component to leave the oil in gaseous form, it will follow that if absorption occurs, the driving force must of necessity be greater than the escaping tendency, and that when these forces have reached the point of equilibrium there can be no further absorption and maximum extraction has been attained.

The proper selection of an absorption oil suitable to obtain maximum absorption is of major importance. In most cases the oil is determined by the still design. However, it is frequently necessary to consider the absorption pressure, percent overload on the absorption unit, and the absorber design.

The Absorption Medium

Absorption oils may be divided into three classifications that are termed: light oils, medium oils and heavy oils. The light oil generally is used in plants having equipment of such nature that close fractionation is possible, and the heavier oils generally are used in the older type units where top temperatures are held by means of water reflux rather than by gasoline reflux. An ideal oil is one that has as low an initial boiling point as possible, low molecular weight, low end point, and narrow boiling range. The ideal absorbent would be a pure compound, but the prohibitive cost of an absorbent of this type makes it necessary to substitute the best that can be reasonably obtained in an absorption oil of narrow boiling range. Light oils usually have a boiling range of from 350 to 500° F., API gravity of from 42 to 44, and molecular weight of from 160 to 180. A medium oil will be found to be of usually 38 to 42 API, with a boiling range of from 390 to 600° F., and a molecular weight of from 180 to 220. The heavy absorption oils are usually of the gas oil type and range in gravity of from 34 to 38 API, and are of slightly wider boiling ranges, usually of from 480 to 750° F., and a molecular weight of from 220 to 250.

There are several advantages to using a lightweight oil, the chief of which are: low viscosity, lower specific gravity, and lower circulation rates. The low specific gravity permits the oil to more completely atomize in the absorber. This tends to increase the absorption area and for the same absorption efficiency and gas throughput this increase in the absorption area will permit the lowering of the gas/oil ratio. It has been authoritatively reported that with each increase in gravity of 1 degree, the absorption efficiency will increase 2 percent. It has also been estimated that the effect of temperature on absorption efficiency is in about the same ratio, that is, for every decrease in oil temperature of 1 degree, the absorption factor will be increased by approximately 2 percent. In the actual operation of absorption units, it has been found that for the same extraction, if the oil temperature is lowered 10° F., the oil rates can be lowered approximately 20 percent, all other conditions remaining the same. The Presaturation Process described in the May, 1940, issue of THE REFINER has contributed much in the way of

reducing oil rates by the introduction of oil on the top plates of the high-pressure absorption units that has already been partially saturated with methane, ethane, and propane constituents. Since the oil introduced on the top plates in this process has a certain volume of these constituents absorbed, there will be little further absorption of these constituents in the top of the absorber and consequently a lower top temperature results in higher extraction efficiency and a consequent lowering of the oil rate for the same efficiency.

Absorption oil will deteriorate with use. As it grows older the gum content will increase. Along with the increase in gum content will be found an increase in end point, specific gravity, demulsibility, carbon-residue content, and sulphur percent. The increase in gum content is perhaps the most important factor to consider in the determination of the deterioration of the absorbent. The demulsibility of the oil will reflect the degree of emulsion that will take place in the absorbers and still and consequently is reflected in the efficiency of absorbility. When the gum content increases in the absorbent, gummy deposits occur in the heat exchangers and on the trays in the towers. This deposition cuts down on the heat transfer between the hot and cold oils in the heat exchangers and on the efficiency of the absorber as well as the absorptive quality of the oil.

The absorption of gasoline constituents from a rich gas is considered to be basically a physical process influenced by various important factors or variables that influence the yield. It is not considered to be a chemical process or reaction, although it is often considered to be such by the layman. The variable factors influencing the process efficiency are: pressure, temperature, area of exposed absorbent, velocity of gas through the tower, surface tension, viscosity, type and supply of oil, kind and richness of the gas, and the design or efficiency of the equipment.

The Absorber Column

The absorber column is a cylindrical tower or vessel that is essentially made up of the conventional bubble plates, bubble caps, down comers, vapor chimneys, and rolled outer shell. Since the absorber is in actuality a bubble-tower it has passed through the four stages of life that other types of fractionating towers have successively experienced; that is, the packed tower, the plate tower, the perforated-plate tower, and the bubble tower.

The packed tower was a column that was packed with various types of material, such as steel shavings or filings, broken brick, etc. Special fillings were developed for the purpose of increasing the efficiency of the tower such as the Raschig ring. This type tower had as its disadvantages the great height necessary for the obtaining of the desired absorption and its low throughput capacity. Perhaps, its most important objection was its tendency to channel; that is, the gas and oil in seeking the line of least resistance would take different routes in their respective ascent and descent through the tower. The real object of the tower is to provide an intimate contact between the uprising gas and the descending oil. This intimate contact must be efficient or the tower efficiency is lowered substantially, and for that reason channeling does not tend toward efficient extraction.

If the plate tower was ever used for absorption purposes, it could not have been used to any success. In this type tower the plates extended only a part of the way across the tower, each succeeding plate being fastened to the opposite side of the column so that the descending fluid would drop from one plate to the next lower. The ascending vapor or gas would have to pass through the curtain of liquid falling from the top to the lower tray and in this manner the ascending and descending materials would come into contact. This method of contacting did not provide the amount of intimacy necessary and for that reason this type tower became extinct as far as absorption purposes were concerned almost as soon as it was introduced to the industry.

Perforated-Plate Tower

The perforated-plate tower, in which the plates were perforated with small round holes and which extended the entire diameter of the column, was much more efficient than either the filled or plate type towers. When the plate was ready for installation it resembled a sieve and for that reason has been often called the "sieve" tower. The liquid on the plates in this type column was kept at the desired level for efficient extraction by the velocity of the uprising gases. Objections to this type tower were that the velocity had to be kept within certain limits and that the capacity was fixed; that the holes rusted easily and often the trays plugged; that too great a velocity would cause the plates to fill up with liquid and too small a velocity would permit the plate to empty itself. A perforated plate has been developed to overcome these objections. This plate has loose rivets inserted in the drilled holes. These rivets slip upward as the gas velocity increases through the column. This upward slip permits the cross-sectional area for the upward going gases to be increased. The decrease in gas velocity is accompanied by a downward drop of the rivets and a consequent decrease in cross-sectional area of the vapor passageways. This type of perforated tray, therefore, permits a wide flexibility of volume and also the necessary intimate contact for efficient extraction.

The column internally constructed with bubble plates and bubble-caps has been developed to overcome all of the objections to the older type towers. This type plate assembly consists of primarily a tray extending across the full diameter of the tower. The tray is drilled or cast with vapor chimneys that are in turn covered by bells or caps constructed with serrated edges, or with the skirts drilled with a number of small holes. The serrated edges or holes in the skirt permit the rising gases to bubble through the liquid covering the tray or deck and in this way provide the intimate contact necessary to efficient absorption. Each tray or deck is provided with one or more downcomers that provide for the continuous drop down of the absorption oil from deck to deck until the base accumulator section is reached. These downcomers are so cast or constructed that the edges act as a weir or dam, holding a constant liquid level at a predetermined constant depth on the plate so that the serrated edges or holes drilled in the cap are constantly covered by liquid. The downcomer outlet on the plate below is surrounded by a weir that holds the liquid around the base of the downcomer at such a depth as to keep any gases from rising to the upper tray except by way of the vapor chimneys. The downcomer on each successive plate is arranged so that it is diametrically opposite from the downcomers on the plates preceding and suc-

ceeding it and so that the absorption oil must flow across the entire diameter of the tower before it can overflow through the downspout to the next lower plate.

Absorber Design

The design of absorption equipment involves data and calculations requiring the application of the laws relating to the conservation of matter and of chemical combining weights and their relation to the quantities and qualities of the materials to be handled in the process; the equilibria data on both the chemical and physical phases of the problem must be given proper respect; and, a consideration of the problem as to its type of reaction, is it mass transfer or is it a chemical reaction. In the design of absorption equipment for the natural gasoline plant, the third part of the problem is quickly determined, it is mass transfer. However, the first two sections of the problem present not only some interesting puzzles, but also some complicated ones. The computations in gas absorption are more easily handled than in other hydrocarbon calculations because of the exact analysis of the hydrocarbon system to be handled that gives the percentage of each constituent present. The major portion of these computations are made using Raoult's and Dalton's laws as a basis. However, at high pressures, that is, pressures exceeding 80 pounds, absolute, Raoult's law does not hold true and equilibrium constants must be used.

The design should certainly be such that the tower will be one of low velocity. The maximum gas rate through any absorber is definitely dependent upon the oil rate, or vice-versa. Entrainment must be kept at a minimum in the absorber and a too high oil rate versus a too high velocity will cause the column to prime and a part of the absorbent will be carried over the top with the residue gas into the scrubbers and even, in some cases of serious priming, into the residue gas lines. The oil rate is dependent in major part on the overflow or downspout pipe capacities, especially so when the downspout capacities have been neglected as a minor item.

The design must take into consideration not only the gas to be processed and the percentage of each constituent that it is required to extract, but also the pressure at which this extraction is to take place and the temperature of the gas and the oil with which it is to be contacted. The necessary absorber capacity, tray spacing, number of trays, gas/oil ratio, diameter of absorber, arrangement and type of bubble caps, number of caps required, and distribution of the flow of the oil over the successive decks are other items that must be considered.

Mechanics of Absorption

There is a wide range of combinations of plate spacings and required number of trays to the absorber. Some companies that operate several gasoline plants standardize on absorbers having a definite number of trays with a definite spacing regardless of the location. The absorbers today range in number of trays from 16 to 28 and the spacings vary from as low as 12 to 36 inches. However, a standard well designed absorber will average about 21 plates and they will be spaced about 20 to 24 inches apart. As a general rule, the greater the tray spacing, the greater the capacity.

The absorption oil enters the absorber on the top tray and flows across that tray before it pours downward to the next lower tray through the downspout. The oil flows across the weir around the base of the downspout and diametrically across the tower to the opposite side where it again overflows through the downspout on that tray to the next lower tray. This procedure is duplicated on each tray until the last is reached. At this point, the oil that flows through the downspout drops into the base of the absorber that is designed so that it acts as an accumulator for the rich oil. The lean oil, as it is called, is the denuded oil or absorption oil that is introduced in the absorber at that point where it will come into contact with the leanest gas. The rich gas is passed into the absorber just below the bottom plate and travels up the tower through the vapor chimneys out through the serrated edges or slots in the caps and bubbles through the oil covering the plates to escape into the vapor space between the plates and by the same detailed routine passes from plate to plate upward until it is released into the open space above the top tray. The gas just before leaving the tower passes through what is called mist extractors. A mist extractor is a mechanical device by which the lean oil carried in entrainment is removed from the lean gas before it leaves the tower to go to the residue scrubber. The residue scrubber is a separator that removes any other traces of oil from the lean gas before it is released from the absorption system by means of back-pressure regulators to the various systems arranged for its disposal.

The contact between the lean oil and the rich gas in the absorber is accompanied by a change of state in the lean oil from a smoothly flowing liquid to a mass of froth composed of literally billions of tiny bubbles. Each bubble is composed of an oil film that has closed around a small portion of the gas and while so enclosing that infinitesimal part of the gas literally draws the gasoline constituents from the methanes, ethanes, and the portions of propane not desired. As the gas rises from tray to tray through the tower it loses at each tray a portion of the gasoline and liquefied-petroleum-gas constituents and so becomes leaner and leaner as it progresses to the top. In turn the lean oil, stripped of all of its gasoline content, drops from tray to tray through the tower and in so dropping from each successive tray becomes richer and richer as it absorbs more of the desired constituents each time it is brought into an intimate contact with the gas that is passing countercurrently through the column.

Factors Effecting Absorption

Since the vapor pressures of the hydrocarbons increase with temperature and the tendency of the hydrocarbon constituent to escape from the oil is the vapor pressure, it is essential that the temperature of the oil and gas be held low. The amount of any particular component that will be dissolved in the oil increases as the temperature of the oil is decreased. It has been established, however, that there is a certain temperature for each particular oil at which absorption is most efficient and at which maximum plant production is obtained. If the oil is too cold, it will become thick and viscous and the proper contact is not obtained in the absorber between it and the gas.

The temperature of the oil leaving the absorber is always higher than the temperature of the oil when it enters the absorber. This is due to the fact that the absorbed constituents pass from a gaseous state to a

liquid state, and in so doing give up their heat of condensation, imparting it to the oil. The temperature of the oil leaving the absorber is the determining factor relative to the amounts of the constituents absorbed. Since the temperature of the oil leaving the conventional type absorber that has no intermediate cooling sections can not be controlled, the temperature of the oil entering the absorber must be established and this in turn will indirectly control the temperature of the rich oil leaving the unit.

The driving force imparted to each constituent in the gas is that force that tends to cause that constituent to go into solution with the oil. This force, or partial pressure of that particular constituent in the gas, is directly dependent on the absorber pressure. Therefore, the higher the absorber pressure, the greater the partial pressure, or driving force. The partial pressure is directly proportional to the absorber pressure (absolute). If the absorber pressure is doubled, the partial pressure or driving force tending toward solution is doubled. As high an absorber pressure as is practical and as consistent a pressure as is possible with the best of automatic back-pressure-regulating devices is to be recommended.

Other factors directly effecting absorption are the characteristics of the absorption medium, gas-oil ratio, velocity of gas through the column, kind of gas, and design of the equipment, all of which have been previously mentioned.

Perhaps, as important a factor as temperature and pressure is the regulation of the gas volume and the oil rate so that both will be as nearly consistent as is possible. It has also been found by many operators that when the oil-gas ratio is higher or lower than a certain definite point maximum efficiency is not obtainable, and at that point of "maximum effect" is acquired the peak of plant production.

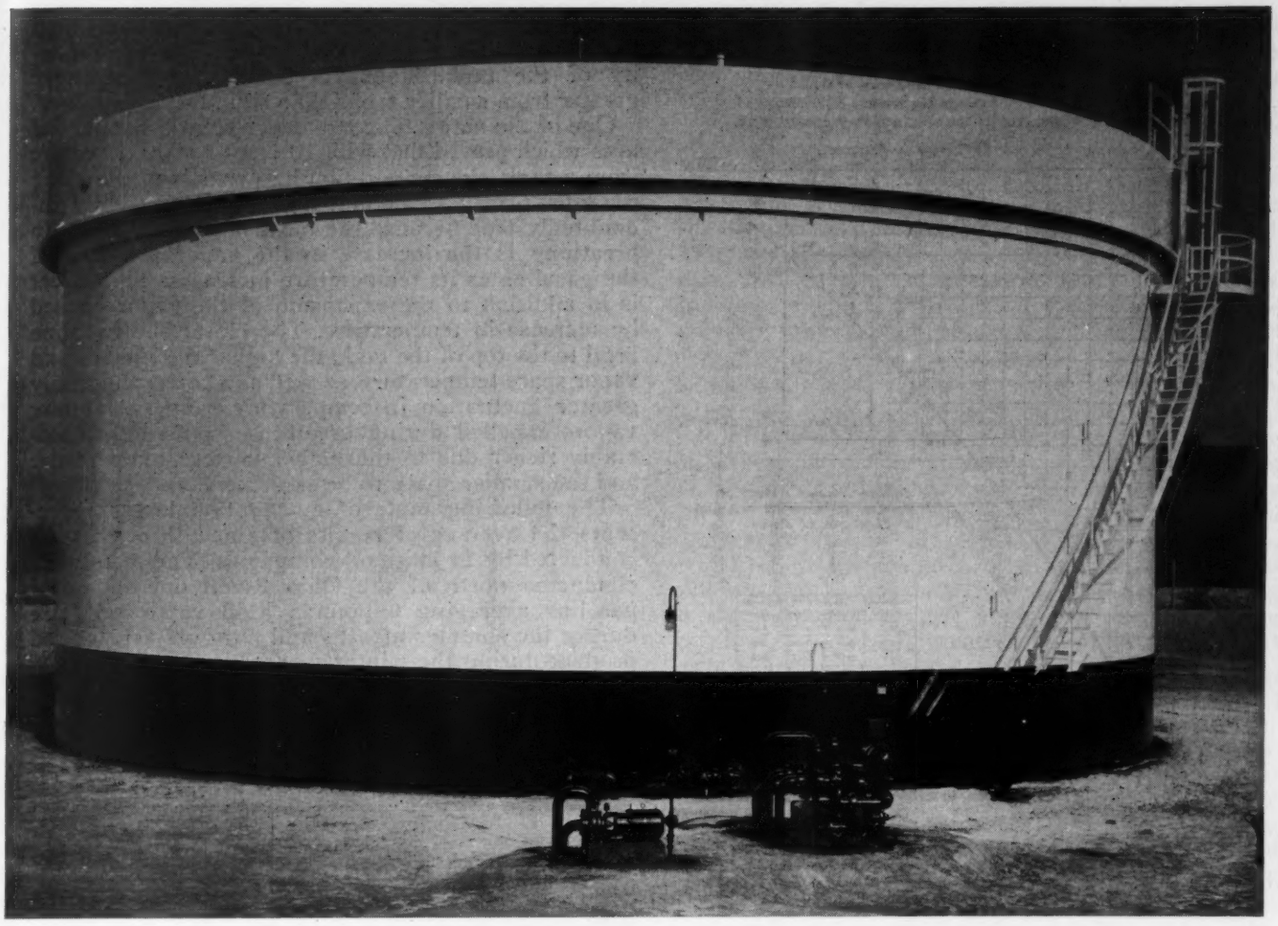
Auxiliary Track for Chain Hoist

FLETCHER OIL COMPANY uses gas engines to operate water pumps in its refinery at Wilmington, California. These engines with their pumps are set in a horizontal row in a concrete sump to lower the suction below the level of the cooling tower basin. Above the series of engines is an I-beam of adequate strength which is supported on the trusses of the roof, originally designed for lateral movement of equipment from one end of the pump room to the other.

To remove a unit from the building while supported by a hoist, a secondary track is employed, one end of which is temporarily attached with bolts to the permanent track. The outer end of the secondary track is equipped with a heavy hook, designed to rest on the wall plate above the studs beneath the eaves of the pump room. The hook, with a wide, flat bearing surface is attached to the web of the secondary track with a stiff connection to prevent distortion and misplacement of the bearing surface between the hook and the wall plate. As the distance from the wall plate to the permanent track is the same at all points, changing position and connecting the secondary track requires only that the hook be placed on the wall plate and the opposite end bolted securely to the permanent track in a position above the engine which is to be taken from the pump room.

When removing one of the engines or pumps, the usual work of backing off the foundation stud nuts is accomplished, followed by placing a chain sling under the unit for lifting. Hooking the chain hoist in the slings permits vertical lifting and when on a level with the outer wall of the sump, horizontal movement is accomplished with ease. The outer end of the secondary track extends a sufficient distance from the eaves of the building so the engine being removed can be lowered to a pick-up or on suitable working benches set up near the building.

If adjustments or repairs are required which cannot be accomplished while the engine is on the foundation, but can be done at the plant without trucking the unit to a machine shop or garage, a skid platform is used which can be laid with one end upon the guard rails, or cribbed up with timbers to the desired height. This skid is made of two 2 x 12 timbers cleated together, which may also be employed as a slide board to slip a unit from the point where it is removed from the sling when the truck or pick-up cannot be backed close enough to load from the hoist. When replacing the unit or engine, the operation is in reverse from the first, and one man using caution and practicing safety can easily make the transfer without calling on additional help.



Evaporation from Gasoline Storage Tanks

C. L. MARNER, Graver Tank & Manufacturing Company, Inc.

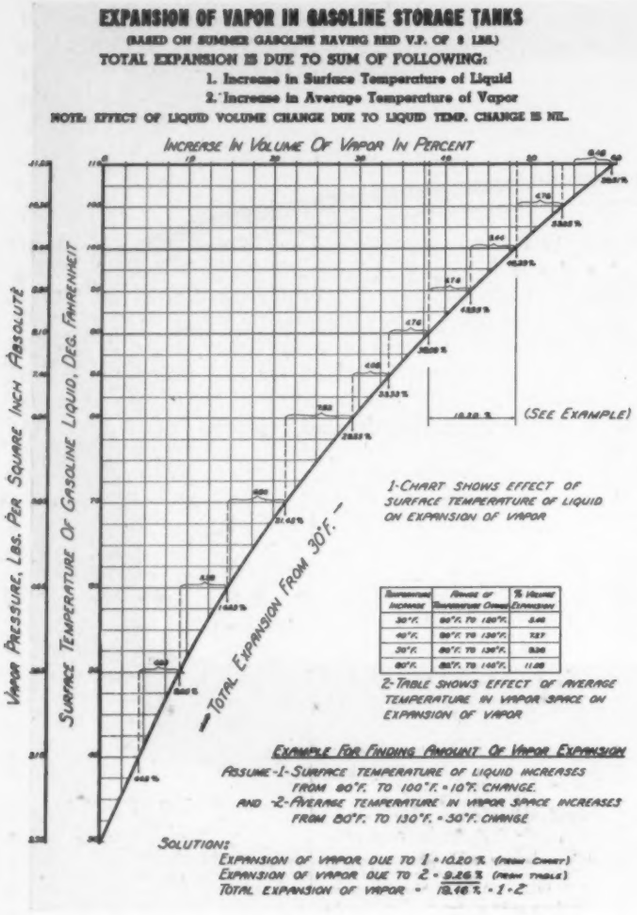
WITH the advent of our active participation in the war, conservation of gasoline has become increasingly important to every one concerned with the production and storage of petroleum products, and particularly high-octane fuels which are considerably more expensive to produce.

The very existence and effectiveness of motorized units, bombing and fighter squadrons, depend essentially upon production and protection of high-octane gasoline. We can build thousands of planes, tanks, jeeps, and other motorized units but unless we protect the volatility and octane rating of our gasoline we materially lower the efficiency of every motor. And when we fail to protect quality we must not forget that we also fail to protect quantity, as volumetric content diminishes as evaporation proceeds.

We are faced with two major problems within the petroleum industry. One of substantially increasing the production of high-octane gasoline for the armed forces, and another of lowering the octane rating of gasoline produced for commercial and domestic markets. The first problem is, of course, the most important; however, the second is of prime importance also as commercial and domestic activities must continue with the least possible interruption in order to insure final victory.

With production of high-octane fuel for war purposes increasing daily and the probable lowering of octane rating to 68 or 70 in gasoline produced for commercial and domestic consumption, evaporation losses should be given serious consideration and immediate steps taken to combat the effect of such losses upon gasoline while it is in storage.

It is apparent that we will have to "rob Peter to pay Paul" in so far as future production is concerned. The limited amount of tetraethyl lead available for gasoline going to commercial and domestic users, because of increased production of high-octane fuel for war use, means that octane rating will have to be lowered. If so, and we then allow an additional drop of from 2 to 3 points during storage periods, we will be creating additional difficulties and lowering


EXPANSION OF VAPOR IN GASOLINE STORAGE TANKS
(BASED ON SUMMER GASOLINE HAVING REID V.P. OF 9 LBS.)
TOTAL EXPANSION IS DUE TO SUM OF FOLLOWING:
1. Increase in Surface Temperature of Liquid
2. Increase in Average Temperature of Vapor
NOTE: EFFECT OF LIQUID VOLUME CHANGE DUE TO LIQUID TEMP. CHANGE IS NIL.
Increase In Volume Of Vapor In Percent
Vapor Pressure, Lbs. Per Square Inch Absolute
Surface Temperature Of Gasoline Liquid, Deg. Fahrenheit
Total Expansion From 30°F.
(See Example)
1-Chart shows effect of surface temperature of liquid on expansion of vapor
2-Table shows effect of average temperature in vapor space on expansion of vapor
Example For Finding Amount Of Vapor Expansion
Assume -1- Surface temperature of liquid increases from 80°F. to 100°F. = 10°F. change.
and -2- Average temperature in vapor space increases from 80°F. to 130°F. = 50°F. change
Solution:
Expansion of vapor due to 1 = 10.20 % (from Chart)
Expansion of vapor due to 2 = 9.26 % (from Table)
Total expansion of vapor = 19.46 % = 1 + 2

the useful life of our commercial and domestic vehicle motors upon which so much depends at this time.

In the production of gasoline whose anti-knock qualities will be barely sufficient to operate modern, high-compression motors without appreciable wear, we should redouble our efforts to investigate and employ every facility available for the protection of the quality of gasoline during storage periods.

Gasoline is composed of hydrocarbons varying in volatility (boiling point). The highly volatile compounds, due to partial pressure effects, vaporize to a greater extent than the heavier, low volatile compounds. These high volatile compounds possess high anti-knock value and if they are removed from the gasoline the result is a pronounced depreciation in quality due to:

1. Decrease in vapor pressure (affects starting)
2. Increase of 10 to 50 percent boiling point (affects acceleration and performance)
3. Decrease in octane number

During recent years much data have been published pertaining to the theory of evaporation; however, little information concerning actual evaporation losses from various sizes of tanks has been made available. In other words, most of us know that we are losing gasoline but few of us know the definite rate of evaporation occurring from tanks of different sizes.

Practically all data covering evaporation have been based on the theory that the loss occurring is directly proportional to the vapor pressure of the product and the surface area of the tank in which the product is stored. However, later information indicates that evaporation loss is directly proportional to the vapor pressure of the gasoline and the capacity of the tank. The loss being correspondingly greater from smaller tanks than from the larger ones.

One of the major oil companies recently completed tests which proved that with 10 feet *or more* of outage from a tank, the evaporation loss remained the same regardless of the amount taken out. This is undoubtedly true because the most important factor in breathing is the increase in the vapor pressure of the gasoline as its temperature increases. This effect is in addition to the expansion of the vapor caused by increase in temperature. The closer the gasoline level to the top of the tank, the higher the surface and vapor space temperature, as well as a correspondingly greater fluctuation in temperature range. And any vapors expelled during breathing would be considerably richer due to the higher surface temperature and the smaller space to be saturated.

The following table of evaporation losses represents the average of results obtained through tests conducted by 14 large oil companies. The tests were conducted north of the Ohio River and on motor gasoline averaging 9 pounds Reid vapor pressure during the summer months and not over a 12 pound product during the winter months.

TABLE 1

EVAPORATION LOSSES — MOTOR GASOLINE

Losses per year from cone roof, gas-tight storage tanks equipped with conventional pressure and vacuum valves.

TANK CAPACITY, BARRELS	Loss Percent of Capacity Per Year	Loss in Gallons Per Year
1,500	5½	3,465
2,500	5	5,250
5,000	4½	9,450
10,000	4	16,800
15,000	3½	22,050
25,000	3½	36,750
37,500	3¼	51,198
55,000	3	69,300
80,000	2.6	87,400

All liquids do not evaporate at the same rate, when other conditions are equal, because of the difference in vapor pressure (tendency to vaporize) of the various liquids.

The various reasons for gasoline losses from cone roof tanks are: windage, breathing, filling, and boiling. The steps necessary to combat these causes of loss are discussed below.

Windage—May be eliminated by making roof and fittings gas tight and also by the installation of pressure and vacuum valves.

Breathing—May be reduced by keeping temperature of liquid surface and vapor space to a minimum. This can be accomplished by spraying water over roofs, using water-top roofs, insulating roofs, employing light-colored paint (aluminum or chalking white), or by protecting tank top and roof with weather hood.

Breathing losses may be eliminated by manifolding vapor spaces of cone-roof tanks to gas reservoirs or to vapor space of tank with variable space roof.

Filling—Roofs of the floating type may be used when product turnover is sufficiently great to make filling losses exceed evaporation losses to such an extent that the additional cost of this type of equipment, over other types, is justified.

Filling losses (also breathing losses) may be eliminated from refinery tankage by having the vapor spaces of all tanks manifolded together and then to a gas reservoir or to a comparatively limited number

TABLE 2

Gasoline Content of Air-Vapor Mixture at Different Temperatures Based on Summer Gasoline Having 9-lb. Reid Vapor Pressure at 100° F.

SURFACE TEMPERATURE	Vapor Pressure	AIR-VAPOR MIXTURE		ATMOS. PRESSURE
		Cu. Ft. Per Gallon	Percent Air, Percent Vapor	Gallons Per M. Cu. Ft.
30° F.	2.5	176	A. 83 V. 17	5.68
40° F.	3.15	140	A. 78.5 V. 21.5	7.15
50° F.	3.83	115	A. 74 V. 26	8.70
60° F.	4.65	95	A. 68.5 V. 31.5	10.52
70° F.	5.65	78	A. 61.5 V. 38.5	12.80
80° F.	6.80	64.8	A. 54 V. 46	15.42
85° F.	7.40	59.6	A. 49.6 V. 50.4	16.75
90° F.	8.1	54.5	A. 45 V. 55	18.34
95° F.	8.8	50.1	A. 40 V. 60	20.00
100° F.	9.6	45.9	A. 35 V. 65	21.75
105° F.	10.3	42.8	A. 30 V. 70	23.30
110° F.	11.25	39.2	A. 23 V. 77	25.55

of tanks equipped with expansion or variable space roofs having sufficient capacity to equal difference in volume of gasoline produced and shipped per day plus proper allowance for breathing.

One major oil company using this method for the past several years reports that tanks containing sweet and sour products have been manifolded without any evidence of contamination of either product.

The same principle may be applied at terminal and bulk storage plants where evaporation losses will be eliminated and filling losses materially reduced. And it can be done at a minimum of expense since, in most cases, only one roof of the variable space type (with sufficient capacity) will completely protect all storage.

Breathing may also be eliminated by storing motor gasoline in 3-pound pressure vessels. When pressure tanks are used the total cost for complete protection is considerably higher than when manifolding cone-roof tanks to roof of the variable space type because each unit must be of the pressure type.

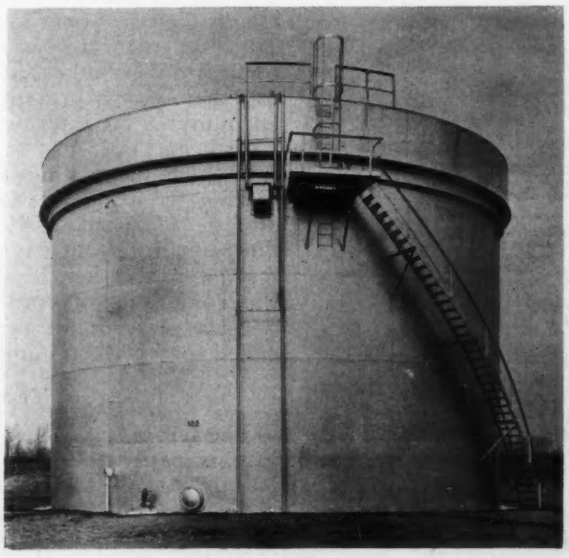
Boiling—Gasolines (natural) that boil at atmospheric pressures under normal operating temperatures should be stored in pressure tanks as boiling stops when the pressure in the vapor space reaches an equality of that of the vapor pressure of the liquid. Thus, vessels designed and built to withstand pressures will prevent evaporation losses from natural gasolines during storage. Several different designs of pressure tanks have been developed for this purpose.

Bulk-Plant Losses—Evaporation loss occurring at bulk plants is most deceptive due to the relatively large coefficient of expansion of gasoline. The variation of atmospheric temperature results in a change of several percent in the volume of gasoline. Because of the fact that gasoline is shipped from the refinery with volume corrected to 60° F., and is delivered to the service station on a strict gallonage basis, it is evident that bulk-plant records do not divulge the amount of gasoline lost due to evaporation during storage. In fact, because a great percentage of the gasoline consumed is greater than 60° F., bulk plant records tend to conceal actual evaporation losses.

Effect of Water on the Quality of Gasoline

Inhibitors are used in gasoline to prevent the oxidation of unsaturated hydrocarbons and thus eliminate formation of gum. Some of these inhibitors are soluble in water. Thus, when water comes in contact with gasoline, the inhibitor loses its effectiveness and as a result, objectionable quantities of gum are formed.

Every man connected with our vast petroleum industry feels that it is his duty to produce gasoline in sufficient quantity to meet every war, commercial and domestic requirement and our wells will supply the oil and our refineries will work night and day until our task is fully completed. But producing and refining is not all that has to be considered. We must protect our gasoline after it is produced so that all of our motorized equipment, for war, commercial, and domestic purposes, will operate without serious interruptions and delays. Protection of gasoline during storage periods will certainly assure this.



Heat Transfer, Pressure Drop, and Fouling Rates of Liquids for Continuous and Noncontinuous Longitudinal Fins

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THIS paper contains test data on continuous and noncontinuous fins for liquids in the laminar-flow region. The data indicate that for longitudinal fin-tube "pipe-within-pipe" type heat exchangers, the transition range begins near R_h=200. Correlation with earlier investigations on air with short longitudinal fins, for R_h>600, indicates fair agreement with the authors' results, when length of fin and inlet turbulence are taken into consideration. Noncontinuous fins promote turbulence in the laminar-flow region and increase fin-side heat-transfer coefficients up to 100 percent, in the range of L=10 feet. The theoretical aspects of fouling on fin tubes versus bare tubes are graphically illustrated, and actual semi-plant-scale fouling rates are plotted. These data show that fin tubes are affected less by fouling than bare tubes, because the effectiveness of the fin increases when fouling becomes greater.

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Statements and opinions advanced in papers are to be understood as individual expressions of their authors and not those of the Society.

TUBES with longitudinal fins cast, welded, or mechanically bonded thereon, have been used industrially for a number of years. These tubes have, in most cases, been manufactured in "continuous" lengths up to 22 feet. Their main application has been for heat-exchange duties covering light fluids such as gasoline, down to the heaviest tars and asphalts. In air heating and cooling, longitudinal fins of much shorter length, 6 inches and less, are quite often used. The heat-transfer coefficients for air, using very short fin lengths, have been obtained, correlated and analyzed by R. H. Norris and W. A. Spofford[3].

Since longitudinal fins for liquids are nearly always used with $L/D_h > 156$, and their structural shapes are somewhat equivalent to flat ducts, the data reported in this paper are more nearly equivalent to Norris and Streid[4].

The data herein reported refer to pipe-within-pipe-type units and are not strictly applicable to other types of fin-tube units.

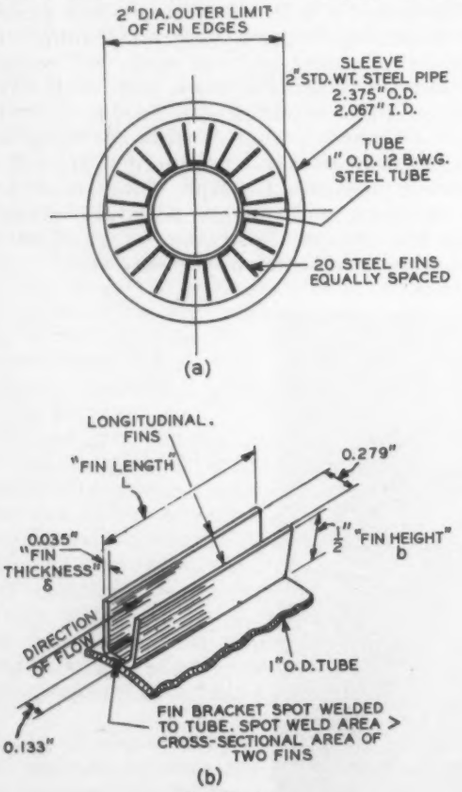

FIGURE 1
Details of double-pipe fin-tube test unit, (a) cross section, (b) enlarged detail of fin bracket.

The present paper has three objectives, as follows:

1 To furnish test data on liquids in laminar flow for long continuous fins, correlated with published data and theoretical curves for air [3, 4].

2 To indicate the advantage of noncontinuous longitudinal fins over long continuous fins for liquids.

3 To present analysis of the theoretical aspects of fouling on fin tubes, as compared with bare tubes, together with a presentation of actual fouling rates encountered in intermittent semi-plant-scale operations.

It must be remembered that the plant-scale conditions of using various fluids from 10,000-barrel storage tanks made it impossible to control inlet temperatures from day to day, and prevented keeping μ constant for the various sets of tests; nor are the conditions of constant surface temperature or constant heat input per unit of length fulfilled, as called for by Norris and Streid[4].

Terminology

The terms "fin height" and "fin thickness," as used in this paper are illustrated in Figure 1. The "fin length," L, is also indicated, but it should be pointed out that on the noncontinuous fins, the term fin length, L, is the continuous length between the cut

Nomenclature

The following nomenclature is used in this paper:

$A = (A_f + A_t)$ = total "exposed" fin-side surface area, sq. ft.

A_c = net free cross-sectional area for flow on the fin side, sq. ft.

A_f = surface area of fins only, sq. ft.

A_i = inside surface area of tube, sq. ft.

A_t = outside surface area of tube only, sq. ft.

b = height of fin (see Fig. 1b), ft.

c = specific heat of fluid, Btu per °F. per lb.

$D_h = \frac{4A_c}{\psi_h}$ = equivalent hydraulic diameter, for determination of heat-transfer coefficient, ft.

$D_p = \frac{4A_c}{\psi_p}$ = equivalent hydraulic diameter, for determination of pressure drop, ft.

f = friction factor, defined by Equation [9], dimensionless.

$G = \rho V$ = mass velocity of fluid, lb. per sq. ft. per hr.

g = acceleration of gravity = 4.17×10^8 ft.per hr.per hr.

h_d = fouling (or deposit) factor, for fin-side fluid, Btu per sq. ft. per °F. per hr.

h_f = fin-side film coefficient (clean), based on A, Btu per sq. ft. per °F. per hr.

h_{fd} = fin-side film coefficient (fouled), (see Fig. 4), Btu per sq. ft. per °F. per hr.

h_i = fin-side film coefficient (h_f), referred to A_i, by correction for effectiveness and tube-wall resistance (see Fig. 4), Btu per sq. ft. per °F. per hr.

h_{id} = fin-side film coefficient (h_{fd}), referred to A_i, by correction for effectiveness and tube-wall resistance (see Fig. 4), Btu per sq. ft. per °F. per hr.

h_t = tube-side film coefficient, Btu per sq. ft. per °F. per hr.

h_w = reciprocal of tube-wall resistance (see Fig. 4), Btu per sq. ft. per °F. per hr.

$J_S = \frac{h_f D_h}{k}\left(\frac{c\mu}{k}\right)^{-1/3}\left(\frac{\mu}{\mu_w}\right)^{-0.14}$ = heat-transfer factor, according to Sieder and Tate,[1] dimensionless.

$J_A = \frac{h_f}{cG}\left(\frac{c\mu}{k}\right)^{2/3}\left(\frac{\mu}{\mu_w}\right)^{-0.14}$ = heat-transfer factor, according to Colburn[3] with Sieder[1] viscosity correction, dimensionless.

k, k_f, k_w = thermal conductivity of fin-side fluid, of fin material, and of wall material, respectively, Btu per sq. ft. per °F. per hr. per ft.

L = length of fin section (see Fig. 2), ft.

Δp = pressure drop of fin-side fluid, due to "friction," psf.

$R_h = \frac{D_h G}{\mu}$ = Reynolds number, based on equivalent hydraulic diameter for heat-transfer coefficient, dimensionless.

$R_p = \frac{D_p G}{\mu}$ = Reynolds number based on equivalent hydraulic diameter for pressure drop, dimensionless.

U_c = over-all heat-transfer coefficient (clean), steam to fin-side fluid, based on A_i, Btu per sq. ft. per °F.—log MTD per hr.

U_d = over-all heat-transfer coefficient (fouled), steam to fin-side fluid, based on A_i, Btu per sq. ft. per °F.—log MTD per hr.

V = linear velocity of fin-side fluid (at A_c), fph.

δ = thickness of fin (see Fig. 1b), ft.

η = effectiveness factor of fin (see Fig. 4), dimensionless.

η' = total surface effectiveness (see Fig. 4), dimensionless.

μ = viscosity of fin-side fluid (evaluated at average fluid temperature), lb. per hr. per ft.

μ_w = viscosity of fin-side fluid (evaluated at tube-wall temperature), lb. per hr. per ft.

ψ_h = total wetted perimeter of heat-transfer surface (fins plus outside of tube), for heat-transfer coefficient only, ft.

ψ_p = total wetted perimeter of heat-transfer surface (fins plus outside of sleeve), for pressure drop only, ft.

ρ = density of fin-side fluid, lb. per cu. ft.

sections, as shown in Figure 2, and may consist of two, four, or more sections; however, only the length of each section is considered in the L/D_h ratio.

Resume of Tests

The majority of the tests made utilized the size and type of fin tube and sleeve illustrated in Figure 1. Other tests were run utilizing fin tubes up to 4 inches in diameter with varying fin spacing, and ¾ inch fin height, which are not reported in this paper. As indicated in Figure 1, steel fins ½ inch in height and 0.035 inch in thickness were used from which fin effectiveness could be readily calculated by the method presented by Harper and Brown[5] (see Figure 4).

The scope of the 300 tests herein reported is shown in Table 1.

TABLE 1
Range of Variables Covered in Tests.

Fluid characteristics	See Table 5
Steam temperatures, F	250 to 325
Average oil temperatures, F	115 to 235
Linear velocity, fps	0.3 to 10
$\left(\frac{\mu}{\mu_w}\right)^{0.14}$	0.85 to 1.9
$\frac{c\mu}{k}$	5 to 5000
L/D_h	37.6 to 313

Correlation of Heat-Transfer Data

The original choice of correlation was based on

$$J_S = \frac{h_f D_h}{k}\left(\frac{c\mu}{k}\right)^{-1/3}\left(\frac{\mu}{\mu_w}\right)^{-0.14} \quad \text{[1]}$$

according to Sieder and Tate[1] for the following reasons:

FIN SAMPLE DESIGNATION	TYPE OF FIN SURFACE AND L/D_h-RATIOS	FIN ARRANGEMENT AND DIMENSIONS (SEE ALSO FIG. 1) DIRECTION OF FLOW →	AVG. TEST RESULTS (ALL DIMENSIONLESS): HEAT TRANS. FACTOR J_A @ R_h=30	FRICTION FACTOR f @ R_p=23.4	PRESS. DROP EFF. FACTOR J_f (1/2)
A-1	CONTINUOUS: L=10' (L/D_h=313)	L	0.028	0.66	0.085
A-2	CONTINUOUS: L=5' (L/D_h=156)	L	0.035	0.69	0.101
A-3	NON-CONTINUOUS: L=2.45' (L/D_h=76.8)	L, ¾", 10'-0"	0.039	0.77	0.101
A-4	NON-CONTINUOUS L=2.45' (FIN ENDS BENT) (L/D_h=76.8)	L, ¾", 10'-0"	0.044	0.87	0.101
A-5	NON-CONTINUOUS: L=1.2' (FIN ENDS BENT) (L/D_h=37.6)	L, ¾", 10'-0"	0.056	0.95	0.118
A-6	NON-CONTINUOUS: L=4.97' (SEGMENT TWISTED) (L/D_h=156)	L, ¾", 10'-0"	0.035	0.70	0.10
A-7	NON-CONTINUOUS: L=2.45' (SEGMENT TWISTED) (L/D_h=76.8)	L, ¾", 10'-0"	0.044	0.88	0.10
A-8	NON-CONTINUOUS: L=2.45' (FIN ENDS BENT, SEG. TWISTED) (L/D_h=76.8)	L, ¾", 10'-0"	0.044	0.88	0.10
A-9	NON-CONTINUOUS: L=1.2' (FIN ENDS BENT, SEG. TWISTED) (L/D_h=37.6)	¾", 10'-0"	0.056	0.99	0.113
N-7	[THEORETICAL EXTRAPOLATION] "FLAT FINS"-CONTINUOUS (L/D_h=11.1)	L, 6", 0.311", 0.010" THICK FINS	@R_h=30: 0.062	@R_p=30: 0.867	0.189

FIGURE 2
Tabulation of heat transfer, friction and pressure drop efficiency factors for fluids.

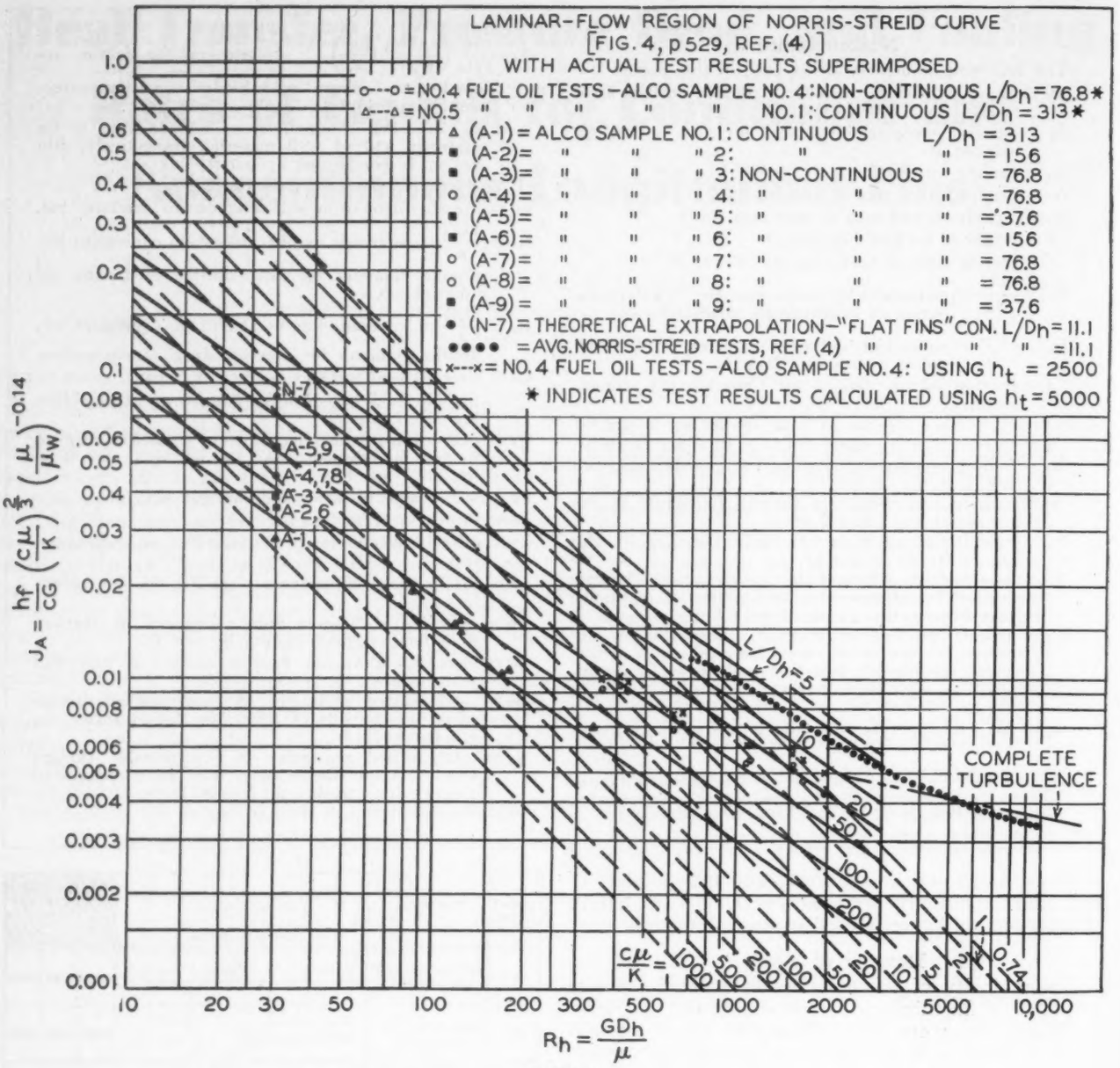
LAMINAR-FLOW REGION OF NORRIS-STREID CURVE
[FIG. 4, p 529, REF. (4)]
WITH ACTUAL TEST RESULTS SUPERIMPOSED
o---o = NO.4 FUEL OIL TESTS – ALCO SAMPLE NO. 4: NON-CONTINUOUS L/Dh = 76.8*
Δ---Δ = NO.5 " " " " " NO.1: CONTINUOUS L/Dh = 313*
Δ (A-1) = ALCO SAMPLE NO. 1: CONTINUOUS L/Dh = 313
■ (A-2) = " " " 2: " " = 156
■ (A-3) = " " " 3: NON-CONTINUOUS " = 76.8
o (A-4) = " " " 4: " " " = 76.8
■ (A-5) = " " " 5: " " " = 37.6
■ (A-6) = " " " 6: " " " = 156
o (A-7) = " " " 7: " " " = 76.8
o (A-8) = " " " 8: " " " = 76.8
■ (A-9) = " " " 9: " " " = 37.6
• (N-7) = THEORETICAL EXTRAPOLATION – "FLAT FINS" CON. L/Dh = 11.1
•••• = AVG. NORRIS-STREID TESTS, REF. (4) " " " " = 11.1
x---x = NO. 4 FUEL OIL TESTS – ALCO SAMPLE NO. 4: USING ht = 2500
* INDICATES TEST RESULTS CALCULATED USING ht = 5000
N-7
A-5,9
A-4,7,8
A-3
A-2,6
A-1
L/Dh=5
10
20
50
100
200
COMPLETE TURBULENCE
cμ/K = 1000 500 200 100 50 20 10 5 2 1
1/2
0.74
1.0
0.8
0.6
0.5
0.4
0.3
0.2
0.1
0.08
0.06
0.05
0.04
0.03
0.02
0.01
0.008
0.006
0.005
0.004
0.003
0.002
0.001
10 20 30 50 100 200 300 500 1000 2000 5000 10,000
$J_A = \frac{h_f}{cG}\left(\frac{c\mu}{K}\right)^{2/3}\left(\frac{\mu}{\mu_w}\right)^{-0.14}$
$R_h = \frac{GDh}{\mu}$

FIGURE 3

Correlation of test data with Norris and Streid's suggested curve (reference, Figure 4).

1 This method would give one curve for both heating and cooling using L/D_h parameters.

2 From a practical rating standpoint, it provided the most convenient form for everyday use.

Therefore, all original data were calculated on this basis, using $h_t = 5000$ for the steam-film coefficient. This procedure introduced a factor of safety for h_f on an average of approximately 8 percent. This is shown in Figure 3, as a replot for No. 4 fuel oil.

For the purpose of correlating data reported in this paper with Norris and Streid[4] the ordinate expression

$$J_A = \frac{h_f}{cG}\left(\frac{c\mu}{k}\right)^{2/3}\left(\frac{\mu}{\mu_w}\right)^{-0.14} \quad \text{.....[2]}$$

was used, and these values are shown in Figures 2 and 3.

As stated in the introduction, the tests on liquids herein reported are governed by L/D_h parameters, since all exceed the limiting values given by Equations [27] and [28] in reference[4]. However to correlate tests on liquids at various temperatures and linear velocities, it is necessary to use the $\left(\frac{\mu}{\mu_w}\right)^{0.14}$ ratio as outlined by Sieder and Tate[1]. Further, to compare test results from different tubular units with different fluids, resort must be made to the Grashof number corrections as outlined by Colburn[2] and Sieder and Tate[1].

Figure 2 has been set up from averages of actual test results to indicate the advantage of changing a long continuous fin tube into a long tube with short noncontinuous sections and turbulence promoters separating the sections. It will be noted that J_A increases up to 100 percent with the L/D_h ratio decrease and that $J_A/(f/2)$ of reference[3] remains substantially constant.

The J_A value for sample N-7 is the theoretical value at $R_h = 30$ for L/D_k taken from Figure 4, reference[4] as there are no test data for air at this Reynolds number. There is no difference in $R_h = 30$ and $R_p = 23.4$,

for D_h and D_p definitions give different wetted perimeters for heat transfer and pressure drop as shown in the nomenclature.

The choice of $R_h = 30$ for the tabulation was predicated on the fact that, between $R_h = 100$ and 200, the authors' test results indicate the transition range between laminar and turbulent flow begins. Numerous repeat tests were made to check this point, all giving materially the same result. This fact was believed to be due to the shape of the passages between the fins. Close inspection of Figure 1 will show that the flow area of the test exchanger is an annular space divided into 20 small trapezoids (depth to width ratio = 0.41) by the fins. Therefore, better correlation was anticipated with published test data for flat or noncircular ducts.

Davies and White[6] have investigated the isothermal flow of fluids in tubes of various shapes. They found that, in the turbulent-flow region, the friction factors for all shapes were in substantial agreement. However, in the laminar-flow region, for shapes other than circular, they point out that the slope of the curve may not be 45 degrees, and the friction factors in general are higher. Further, it was determined that the transition range between laminar and turbulent flow might begin as low as $R_h = 200$ for noncircular shapes.

Since the heat-transfer coefficient h_f normally increases with the increase of friction factor f, it would be expected, in view of Davies and White's data[6] that the test results herein reported would show higher J_A values and the transition range beginning well below $R_h = 2100$.

The results, as plotted in Figure 3, indicate surprising agreement with this hypothesis. It is not intended, in this paper, to cover the entire range of tests in the laminar-flow region, nor to draw final conclusions as to the proper correction for shape factor in Equations [1] or [2], as these items are being reserved for further study. It is sufficient at this time to state that the L/D_h parameter curves, in Figure 4 of reference[4] are conservative for liquids in the range of $R_h = 150$ to 2100, for the test unit described in Figures 1 and 6 of this paper.

In considering the economic aspects of normal heat-exchanger design for liquids in the laminar-flow region, it will be found that for, say, steam heaters, the Reynolds number spread of 1 to 2100 covers a number of liquids as shown in Table 2.

To indicate this condition from test results and to show the shift in transition range, Figure 3 has been included, which plots average values for Figure 2 (pressure-still residue and asphalt) and test results for Nos. 4 and 5 fuel oils. The pressure-still residue and asphalt tests (Figure 2) were run at average values, $\left(\frac{\mu}{\mu_w}\right)^{0.14} = 1.5$ to 1.9, $\frac{c\mu}{k} = 2000$ to 5000. The Nos. 4 and 5 fuel-oil average test values were $\left(\frac{\mu}{\mu_w}\right)^{0.14} = 1.1$ and 1.26; $\frac{c\mu}{k} = 61$ and 333, respectively.

TABLE 2

Data Showing Reynolds Numbers Versus Types of Oils Normally Encountered in Steam Heaters.

Type of oil	Reynolds number range
Gasoline, kerosine	>2300
Light burning oils (1, 3, and 4)	200 to 8000
Medium fuel oils (No. 5)	80 to 300
Heavy fuel oils and asphalts	<100

NOTE: Limiting range—temperature 80 to 350 F; linear velocity 0.3 to 8 fps.

Linear velocities ranged from 0.3 to 5 fps, in all cases.

In addition, Figure 3 shows a plot of Norris and Spofford's[3] actual test results for sample N-7. It will be noted that the J_A values are above the $L/D_h = 11$ parameter line. The tests in this paper do not cover an L/D_h value as low as 11, although extrapolation from the values between $L/D_h = 313$ and 37.6, to $L/D_h = 11$, indicates agreement within 10 percent.

Colburn[2] suggested the use of the Grashof number as a correction to the equation of the empirical line for viscous flow as follows:

$$\psi = 1.5 \left(\frac{\mu}{\mu_f}\right)^{1/3} (1 + 0.015\ Gr^{1/3}) \quad [3]$$

(where μ_f is viscosity at film temperature)

Sieder and Tate[1] suggest the correction of h_f by a modified form of Equation [3] when dealing with gases or light liquids. (Here μ in the Grashof number is taken at average stream temperature):

$$(0.8 + 0.012\ Gr^{1/3})\ h_f \quad [4]$$

A brief check using Equations [3] and [4] with air at 70° F. and $R_h = 700$ shows that the test unit for sample N-7 should give approximately a 10-percent higher J_A value than the test unit in this paper, assuming L/D_h values are equal. This point is more or less academic since neither unit was tested on both liquids and air.

The equation for J_A in the laminar-flow region, as indicated in Figure 3, where L/D_h parameters are controlling, is

$$J_A = 1.85\ (L/D_h)^{-1/3}\ (R_h)^{-2/3} \quad [5]$$

This equation is conservative in the range $R_h > 100$ and may be as much as 40 percent low at $R_h = 2000$ with $L/D_h = 313$ for the test unit herein described. As stated earlier in this paper, the final solution of the foregoing variation must await further study of the data accumulated.

In view of the preceding points, it is obvious that the thermal engineer must be careful, in selecting h_f, to give critical consideration to such factors as $\left(\frac{\mu}{\mu_w}\right)$; the shape and alignment of fins; the geometry of fin passages; etc. These factors may tend toward cumulative effects which would radically modify theoretical analysis or extrapolations of test results. Fortunately, the use of Figure 4, reference[4], is on the conservative side for liquids and can be used with safety in ordinary cases.

Practical Applications

The data herein presented give an indication of the improvement that can be expected in the laminar-flow region for liquids by taking tubes with long continuous fins and altering the latter to relatively short noncontinuous sections. This procedure still maintains the economic advantage of long heat-exchanger shell construction with increases in over-all rates up to 100 percent; it also preserves the desirable feature of ease of cleaning.

General Considerations. Published data on fouling rates for fin tubes are negligible at present. The data in this paper cover the theoretical aspects, together with actual results of semi-plant-scale operations.

As it happens, most longitudinally finned tube services cover the use of a relatively clean fluid (such as steam or water) on the inside of the tube, or the use of a dirtier fluid at linear velocities near or above the scouring range.

Therefore, in comparing longitudinal fin tubes with bare tubes, the main concern is with the fouling rate

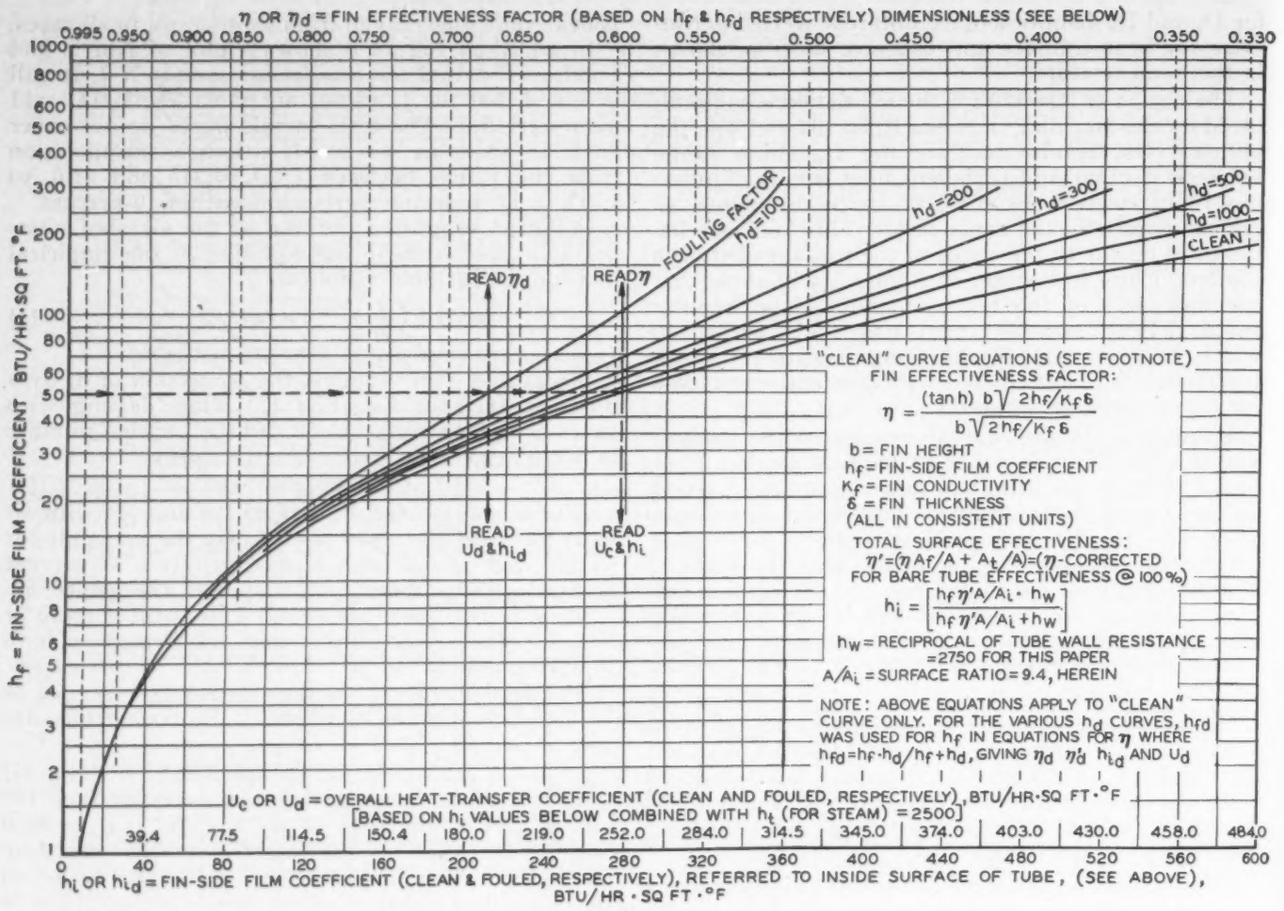
η OR ηd = FIN EFFECTIVENESS FACTOR (BASED ON hf & hfd RESPECTIVELY) DIMENSIONLESS (SEE BELOW)
0.995 0.950 0.900 0.850 0.800 0.750 0.700 0.650 0.600 0.550 0.500 0.450 0.400 0.350 0.330
hf = FIN-SIDE FILM COEFFICIENT BTU/HR·SQ FT·°F
FOULING FACTOR
hd=100
hd=200
hd=300
hd=500
hd=1000
CLEAN
READ ηd
READ η
READ Ud & hid
READ Uc & hi
"CLEAN" CURVE EQUATIONS (SEE FOOTNOTE)
FIN EFFECTIVENESS FACTOR:
η = (tanh) b√(2hf/Kfδ) / b√(2hf/Kfδ)
b = FIN HEIGHT
hf = FIN-SIDE FILM COEFFICIENT
Kf = FIN CONDUCTIVITY
δ = FIN THICKNESS
(ALL IN CONSISTENT UNITS)
TOTAL SURFACE EFFECTIVENESS:
η' = (η Af/A + At/A) = (η-CORRECTED FOR BARE TUBE EFFECTIVENESS @ 100%)
hi = [hf η'A/Ai · hw] / [hf η'A/Ai + hw]
hw = RECIPROCAL OF TUBE WALL RESISTANCE = 2750 FOR THIS PAPER
A/Ai = SURFACE RATIO = 9.4, HEREIN
NOTE: ABOVE EQUATIONS APPLY TO "CLEAN" CURVE ONLY. FOR THE VARIOUS hd CURVES, hfd WAS USED FOR hf IN EQUATIONS FOR η WHERE hfd = hf·hd/(hf+hd), GIVING ηd η'd hid AND Ud
Uc OR Ud = OVERALL HEAT-TRANSFER COEFFICIENT (CLEAN AND FOULED, RESPECTIVELY), BTU/HR·SQ FT·°F
[BASED ON hi VALUES BELOW COMBINED WITH ht (FOR STEAM) = 2500]
39.4 77.5 114.5 150.4 180.0 219.0 252.0 284.0 314.5 345.0 374.0 403.0 430.0 458.0 484.0
hi OR hid = FIN-SIDE FILM COEFFICIENT (CLEAN & FOULED, RESPECTIVELY), REFERRED TO INSIDE SURFACE OF TUBE, (SEE ABOVE), BTU/HR·SQ FT·°F

FIGURE 4

Theoretical effects of fouling rates on longitudinal fin tube (1 inch OD, 12 BWG steel with 20 steel fins, ½ inch high by 0.035 inch thick attached).

and its effects on the fin side, or in the case of bare tubes, on the outside surface.

Theoretical Considerations. Sieder[7] gives a very good résumé and proposed method for calculating fouling rates for bare tubes, which has been used in this paper.

The generalized equation for flow of heat from one fluid to another for bare tubes, with tube-wall and fouling resistance ignored is

$$\frac{1}{U_c} = \frac{1}{h_f} + \frac{1}{h_t} \quad \ldots\ldots [6]$$

In commercial practice, a fouling factor is applied and the equation becomes

$$\frac{1}{U_d} = \frac{1}{h_f} + \frac{1}{h_t} + \frac{1}{h_d} \quad \ldots\ldots [7]$$

However, in the case of fin tubes, the additional factor of fin effectiveness must be considered. Further, because of the high ratio of $\frac{A}{A_t}$, the tube-wall resistance to the flow of heat is appreciable and cannot be ignored. The equation then becomes

$$\frac{1}{U_d} = \frac{1}{h_{id}} + \frac{1}{h_{td}} \quad \ldots\ldots [8]$$

where

$$h_{id} = \frac{h_{fd}\,\eta'\frac{A}{A_i}\cdot h_w}{h_{fd}\,\eta'\frac{A}{A_i} + h_w}$$

The fin effectiveness factor η of reference[5] and total surface effectiveness factor η' are described in Figure 4.

Figure 4 has been prepared for the tube in Figure 1, based on the equations noted therein, and plots h_f versus h_i versus U versus η with various fouling factors applied. From a study of Figure 4, it is immediately evident that fouling affects the fin effectiveness factor η appreciably, always increasing the effectiveness. This gives the fin tube a decided advantage over bare tubes when fouling is considered.

As an example, a point $h_f = 50$ with $h_d = 100$ is indicated in Figure 4, in heavy black lines. This gives $U_c = 250$ and $U_d = 192$, or the decrease due to fouling effect on U was 23 percent. The fin effectiveness factor η was 0.598 at $h_f = 50$ and 0.67 fouled, or a 12-percent increase. For a bare tube at the same h_f and h_d, using Equations [6] and [7], it is found that $U_c = 49$ and $U_d = 33$, or the decrease due to fouling was 33 percent. Thus, it is seen that fouling has less effect on fin tubes, as compared to bare tubes, when considering outside surface. In addition, it is obvious that the increase in the fin effectiveness factor η when fouling occurs, is the factor responsible for the advantage.

The increase in η due to fouling is less at lower values of h_f and varies as the hyperbolic tangent with variations in h_f or h_d.

Another inherent advantage in fin tubes is that, in heating liquids which have a tendency to coke or form heavy polymers, the fin-surface temperatures are lower than with bare tubes due to η, with conse-

quent less fouling. Conversely, in cooling, the fin surfaces are at higher temperatures with less tendency to deposit tars, etc.

Test Results. Figure 5 is a plot of actual test results from intermittent semi-plant-scale test runs reported in this paper (see Appendix, "Test Procedure"). The test shown for the commercial fin-tube tank-suction heater was on a 24-inch-diameter unit, in bunker "C" fuel-oil service at a major oil company's plant.

It is well known that intermittent operation increases fouling rates above continuous operation, because of oxidation, stagnant-fluid conditions, etc. For this reason, the data, shown in Figure 5, should be considered as on the high side. However, it does indicate that, for most fuel-oil heaters with steam temperatures not greater than 350° F, an applied fouling rate of $h_d = 200$ to h_f, should result in at least 1 year of operation without cleaning.

In Figure 5, a semi-Navy-type fouling test is indicated (Δ), which consisted of leaving the unit full of pressure-still residue for 18 hr, with 80-psi steam inside the tube. Test runs before and after the fouling period gave the fouling factor noted. A dotted line over to the average plot curve shows this test approximating a 1-year operating period for fuel-oil service without cleaning.

It should be pointed out that the tendency for fuel oils to break down with time and elevated temperatures varies considerably. The fuel oil used for the semi-Navy-type test was a 6° API pressure-still residue from cracking operations at 900° F., which should be comparable to most bunker "C" fuel oils on the market.

On the lighter oils, very little fouling was encountered beyond that expected for intermittent operations.

Standard Fouling Factors. The Tubular Exchanger Manufacturers Association (T.E.M.A.)[8] has set up standard fouling factors, based on actual plant experience, over a period of many years. The fouling factors which are applicable to data reported in this paper have been excerpted from reference[8] and are shown in Table 3. It will be noted that the test data check well in line with the T.E.M.A. Standards.

Correlation of Pressure-Drop Data

All the original pressure drop test data covered in this paper were evaluated by use of the modified form of the general Fanning equation, as outlined by Sieder and Tate[1], who introduced the function $\left(\frac{\mu}{\mu_w}\right)^{0.25}$ to make it applicable to all fluids.

For purposes of correlation with data presented by Norris and Spofford[3], the generalized Fanning equation was used with $\left(\frac{\mu}{\mu_w}\right)^{0.25}$ function added

$$f = \frac{gD_p\Delta P}{2\rho V^2 L}\left(\frac{\mu}{\mu_w}\right)^{0.25} \quad \ldots\ldots\ldots\ldots [9]$$

The pressure-drop results are shown in Figure 2, based on both f and $J_A/(f/2)$.

TABLE 3

Excerpt of Fouling Coefficients from Standards of T.E.M.A. for Various Fluids Used in this Paper.

Fluid	Fouling Coefficient, h_d
Industrial fuel oil	200
Residual bottoms, less than 25° API	200
Distillate bottoms, 25° API or above	500
Side stream cuts (Nos. 1, 2, 3, and 4, fuel oils) atmospheric dist. units	770
Steam (nonoil-bearing)	0
Steam, exhaust (oil-bearing, from reciprocating engines)	1000

TABLE 4

Correlation of Friction Factors in Laminar-Flow Region.

Reynolds Number, (R_p)	Sample No. and L/D_h Ratio	FRICTION FACTOR f: Hagen-Poiseuille Curve	Rectangular Ducts Per Davies and White[6]: Sample A-1	Rectangular Ducts Per Davies and White[6]: Sample N-7	Authors' Tests* Plotted, Per Eq. (9)	Norris and Spofford N-7 Tests[3]	Davies and White,† Max. Test Values
30	A-1; 313	0.537	Does not apply		0.511‡	.....	0.537
	A-9; 37.6	.....	.....	.....	0.727‡	.....	.....
	N-7; 11.1	.....	.....	.....	.....	.....	.....
600	A-1; 313	0.0265	0.0272	0.0332	.....	.....	0.037
	A-9; 37.6	.....	.....	.....	0.0402‡	.....	.....
	N-7; 11.1	.....	.....	.....	0.0471‡	.....	.....
800	A-1; 313	0.0198	0.0204	0.0249	.....	0.040‡	.....
	A-9; 37.6	.....	.....	.....	.....	.....	0.031
	N-7; 11.1	.....	.....	.....	.....	.....	.....
1000	A-1; 313	0.0158	0.0163	0.0199	.....	0.036‡	.....
	A-9; 37.6	.....	.....	.....	.....	.....	0.0265
	N-7; 11.1	.....	.....	.....	.....	.....	.....

* Authors' tests include end losses.
† Davies and White maximum test values, from reference 6, Figure 2, p. 70.
‡ Average test results.

It will be noted that, for any given fluid, the efficiency factor $J_A/(f/2)$ is substantially a constant when L > 1 ft. and < 10 ft. This means that a long continuous longitudinal fin can be divided into relatively short sections without increasing the total pressure drop beyond that to be expected with the increased heat transfer.

The f value, for sample N-7 in Figure 2, is a theoretical value based on Equation [9] and modified for L = 0.5 ft. in ratio to tests in this paper for short lengths. This procedure was necessary since no test data were available at this point.

Under "Correlation of Heat-Transfer Data," refer-

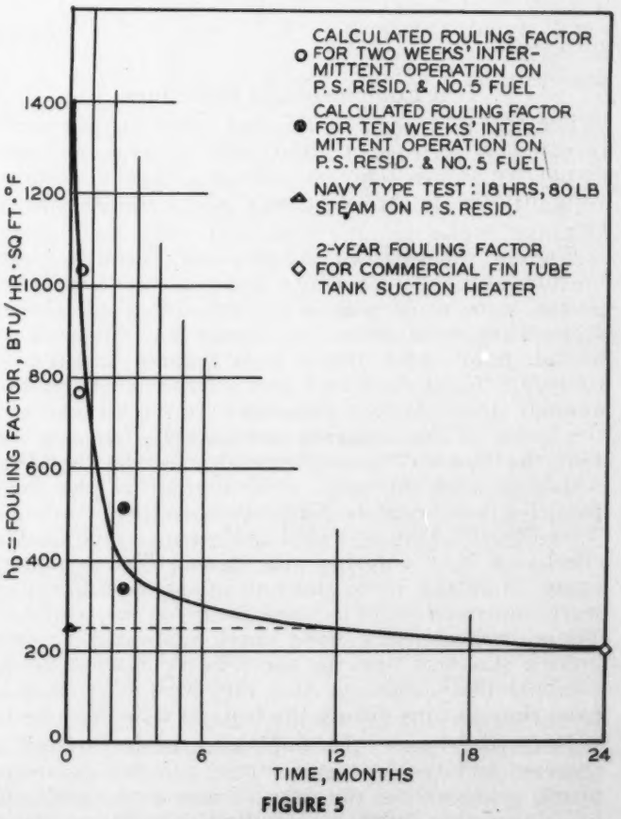

FIGURE 5

Test Data for Fouling Rates

ence was made to Davies and White's report[6] on friction factors covering isothermal flow for pipes of various shapes. They found that noncircular shapes caused disturbances to flow in the laminar-flow region and in some cases, the transition range might begin at a value as low as $R_p = 200$.

To correlate friction factors for the test unit samples A-1, A-9, and N-7 with the Hagen-Poiseuille friction-factor curve for circular shape, and Davies and White's[6] findings, Table 4 is presented.

Sieder and Tate[1] found that circular-tube friction factors for liquids in nonisothermal flow, in the laminar-flow region, would fall on the isothermal f curve when multiplied by 1.1 $\left(\frac{\mu}{\mu_w}\right)^{0.25}$. The evaluations of test data shown in Table 4 have not been corrected by the factor 1.1, as suggested by Sieder and Tate[1].

The Davies and White[6] f values, shown, in columns 4 and 5 of Table 4, are based on rectangular shapes for ratio of depth to width. (The ratios were: A-1 = 0.41; N-7 = 0.156.) It will be noted that sample N-7 correlates better with Davies'[6] maximum limits for shape effects, or with parallel plates, rather than with rectangular shapes. Sample A-1 gave values well above the theoretical rectangular shape effect expected, and more nearly in line with an annular ring or parallel plates. It was originally believed that A-1 would correlate as a rectangle, since its flow area consisted of 20 small trapezoids.

Test data for pressure drop not shown in this paper indicate that the transition range begins somewhere near R = 200, which is in agreement with Davies and White's[6] conclusions.

Sample A-9, f values cannot be compared with samples A-1 or N-7, as it has twisted fins which offer additional resistance to flow.

General Conclusions

Heat Transfer

1. The use of noncontinuous fin sections instead of long continuous fins increases h_f in the ratio of 2 to 1, where L = 1.2 to 10 feet.

2. Correlation to test data for liquids in this paper, where L/D_h is controlling, indicates the curves shown in Norris and Streid's[4] Figure 4, are conservative above $R_h = 200$, because present test results show the transition range beginning at about this point.

3. The dimensionless function $\left(\frac{\mu}{\mu_w}\right)^{0.14}$ should be included in the J_A value when correlating viscous liquids.

Pressure Drop

1. The pressure-drop efficiency factor for noncontinuous fins is comparable to that on long continuous fins where L = 1 to 10 feet.

2. Correlation of test data on pressure drop in this paper with Norris and Spofford[3] gives fair agreement in the range of $R_p = 700$ to 2000 for sample N-7.

Fouling Rates

1. From a theoretical viewpoint, fouling has less effect on fin tubes than on bare tubes, for as fouling increases, the fin effectiveness increases, tending to offset the fouling effect.

2. A fouling factor of 200 for longitudinal fin tubes in heavy-fuel-oil service, with steam temperatures not above 350° F., will normally assure at least 1 year of service without cleaning. Intermittent operations or operations at less than design throughputs may shorten this period.

APPENDIX

Test Equipment and Procedure

The essential items of the test setup for the work reported in this paper (and their general arrangement) are shown schematically in Figure 6, as they were installed in the oil refinery where the tests were run.

Fin-Side Fluid Circuit. As previously mentioned, the fin-tube exchanger on which the test runs herein reported were made was of the "double-pipe" design (pipe-within-pipe type, see Figure 1). The various fin-side fluids were drawn from refinery tankage (5 to 10,000-barrel capacity) and pumped through the annular space between the outside of the fin tube and the inside of the confining outer sleeve. Leaving the unit, the fluid then passed through a mixing chamber, which insured thorough commingling of the fluid particles for accurate outlet-temperature readings. Thermowells were provided as shown to give double checks on both entering and leaving fluid temperatures. Standard industrial-type glass thermometers were immersed in oil in these wells for the readings. These thermometers were check-calibrated against known standard ones in the refinery laboratory to establish their accuracy. Also, they were interchanged from time to time during the tests as a further check.

From the mixer, the fluid next went through a strainer and displacement meter (of the nutating-piston type), where the rates of flow were measured in conjunction with a standard laboratory timer clock, which was check-calibrated occasionally during the progress of the tests. Two sizes of meters were used in the tests to cover the wide range of flow rates run, and these instruments were check-calibrated from time to time during the course of the work to insure their accuracy. Upon leaving the metering device, the fluid then passed into the return piping system to refinery tankage.

Pressure drops across the test unit were measured by a differential-pressure recorder (of the mercury-manometer type). The location of the pressure taps in the inlet and outlet nozzles of the test unit, Figure 6, meant that end losses were included in the pressure drops recorded. It should be pointed out, however, that, since the net free area of the end chambers below the nozzles was essentially equal to that of the nozzle pipes, these end losses therefore were kept to a nominal figure. Further, it must be noted that no calming section was provided to minimize inlet turbulence, since it was desired to approximate an actual commercial installation as closely as possible.

Fluids of various inlet temperatures were used in the work, and the manifold rates of flow which were run resulted in a considerable range of outlet temperatures. To insure further the accuracy of the temperature readings, the essential thermal apparatus was thoroughly insulated as shown. Standard pipe insulation (1-inch-thick magnesia-asbestos) was used for the purpose, since this type readily suited dimensional

and test-condition requirements. Tests for the magnitude of heat leakage through this material were not made, since, for the relatively low temperatures of the test operations, it was known that the possible error from this source would not be greater than 2 or 3 percent.

Steam Circuit. Steam, at various pressures, was used as the heating medium inside of the fin tube. Live steam at refinery boiler-room conditions was taken from the mains and brought to the desired test-pressure requirements by means of the automatic air-actuated diaphragm control valve. The latter was connected to the recording pressure controller and flow-meter instrument, where manual setting of the desired test conditions was effected. A pair of orifice flanges, in conjunction with several interchangeable plates of different orifice sizes, were installed in the meter system to cover the required test range. Suitable piping lengths, as required by the meter installation manual, were strictly adhered to for correct and accurate operation of the meter system. An internally baffled desuperheater chamber was provided as shown, to insure the delivery of substantially dry, saturated steam to the test unit. A Bourdon-type pressure gage also was installed as shown, to give a double check on steam-meter-pressure readings. A trap at the bottom of the desuperheater chamber discharged the water removed from the steam, and this feature, together with observation of the pressure and temperature readings, assured that the desired steam conditions (freedom from superheat and wetness) were reasonably maintained.

At the steam outlet of the unit, it was found necessary to provide the condensate chamber shown, to guard against the possibility of flooding, by backing up condensate within the fin tube. An industrial-type steam trap was installed at the bottom of this compartment to discharge the condensate collected. Occasional blowdowns were made between tests to ascertain that the trap was operating correctly. Standard industrial-type glass thermometers (previously check-calibrated) in suitable thermowells were used for the temperature readings on the steam side.

Test Procedure. On any particular oil, tests were run at 3, 6, 12, 18, 24, and 30 gallons per minute rate, with check tests going back down the scale 30, 24, 18, etc. Each test consisted of four consecutive sets of readings during a 10-minute period after stable conditions were attained. The lower limit of oil throughput was set at 3 gallons per minute, since it was found that any rates of flow below this value gave erratic readings which could not be measured accurately with the existing equipment.

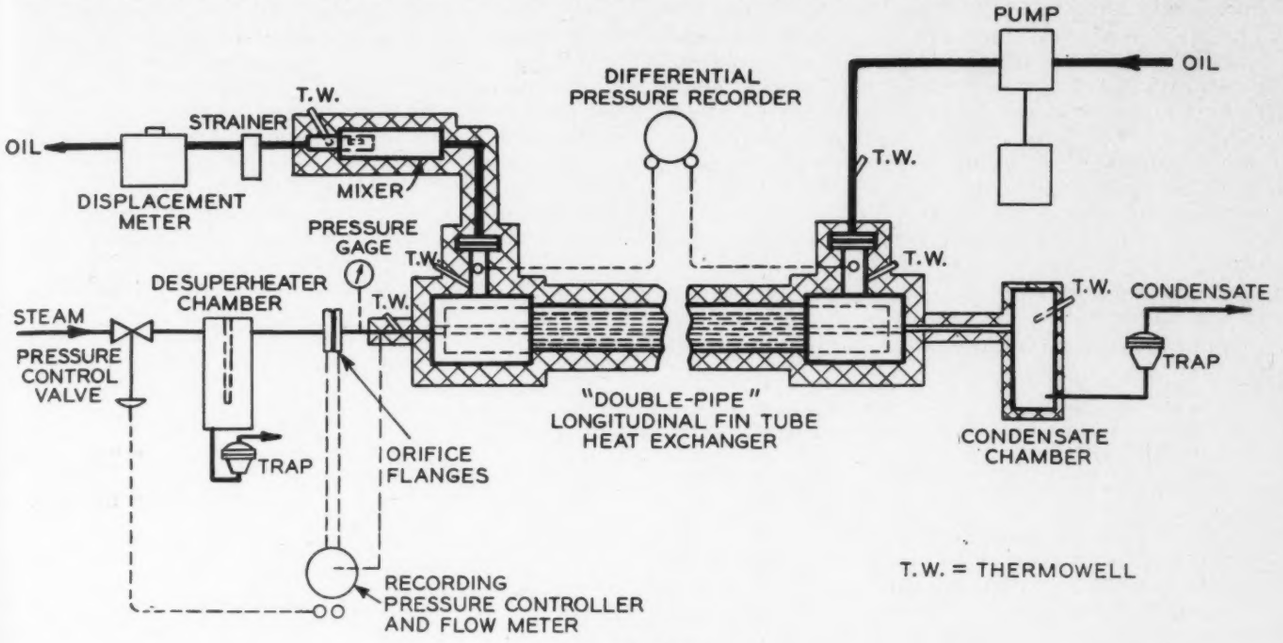

FIGURE 6
Test unit arrangement

For determining fouling rates, the first set of tests run, when the fin tube was new, were repeated at intervals. The difference between the original and repeat values of h_f were then recorded as fouling rates. The tubes used were of the bright annealed type and very little fouling occurred on the inside surface.

Average samples of the oil flowing through the unit were taken and tested in the plant laboratories for gravity and viscosity.

TABLE 5
Characteristics of Fluids Tested.

FLUID	Gravity, °API	VISCOSITY 70 °F. SSU	100 °F. SSU	130 °F. SSU	210 °F. SSU	77 °F. SSF	122 °F. SSF
Naphtha	46.2	...	29	...	...	...	...
No. 2 Burning Oil	35.5	...	34	...	...	...	...
No. 4 Burning Oil	27.1	61	47	...	...	...	...
No. 5 fuel	21.5	...	126	72	...	...	...
Pr. still resid.	7.3	...	...	...	77	...	74
Heavy pr. still resid.	4.4	...	...	...	126	...	159
Cut-back asphalt	18.1	...	681	...	...	149	...

Calculation of Results. Since steam was used inside the tube, for which consistent results are available, the fin side coefficient h_f could be easily calculated, utilizing fin effectiveness curves based on[5], and shown in Figure 4. The over-all heat-transfer coefficient used was

obtained by dividing the total heat transfer by the total surface of the inside of the tube, using the log MTD between the fin-side fluid and the steam.

Since the data from these tests were to be set up for rating purposes, it was decided to use h_t of 5000 instead of 2500, to provide a factor of safety in the rating curves and yet not affect the consistency of the plot. Figure 3 shows a plot of the No. 4 fuel-oil test results as calculated, using $h_t = 5000$ (o) and $h_t = 2500$ (x). The discrepancy introduced in the plot of these data relative to the other results shown is thus graphically illustrated. As stated previously, this introduced the desired factor of safety in the company standard rating curves. The foregoing assumption for the steam-side coefficient h_t, is in line with the film concept of condensation, as presented by Jakob[9]. Verification of this point was established as well as could be accomplished with the existing setup, by passing steam through the unit at a linear velocity considerably in excess of 50 feet per second, and noting no apparent change in the outlet temperature of the oil.

Fluid characteristics were taken from the following sources:

c = specific heat; Standards of T.E.M.A., Figure 20, ref.[8].
k = thermal conductivity; Bureau of Standards Miscellaneous Publications, No. 97.
μ = absolute viscosity conversions; A.S.T.M. Tentative Standard D-341-32T viscosity-temperature chart.

Accuracy. Approximately 5 percent of the plotted results did not give satisfactory agreement and consequently were discarded as being erroneous. The remaining 95 percent were in substantial agreement, the variation being approximately $\pm$ 6 percent from the average. Further, heat balances made during the earlier part of the work (until oil-temperature results were verified satisfactorily) showed variations from 1 to 10 percent, the oil-side duty always showing lower than the tube-side duty.

Acknowledgment

The authors wish to take this opportunity to express appreciation for the contribution to this work made by Mr. A. S. Denton in carrying out part of the tests and subsequent calculation of results. Credit is also due Messrs. S. Kopp and T. F. Fitzgerald for their many helpful suggestions during the test program. Appreciation of the co-operation of Mr. R. H. Norris in making available certain additional data not published in his reference papers and his valuable criticism and comments during the preparation of the present paper, is also hereby expressed. Further, the courtesy of the Tubular Exchanger Manufacturers Association, Inc. in giving permission to quote from its "Standards" is also gratefully acknowledged.

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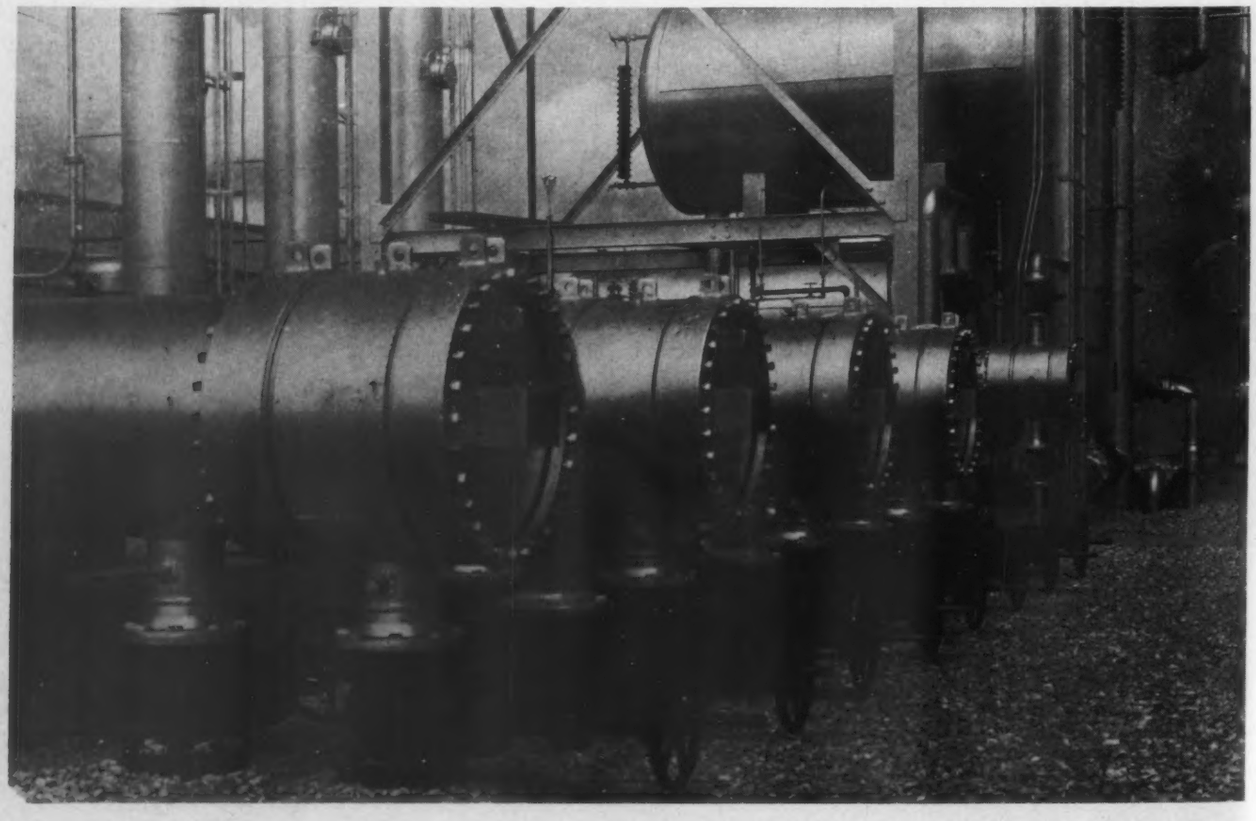
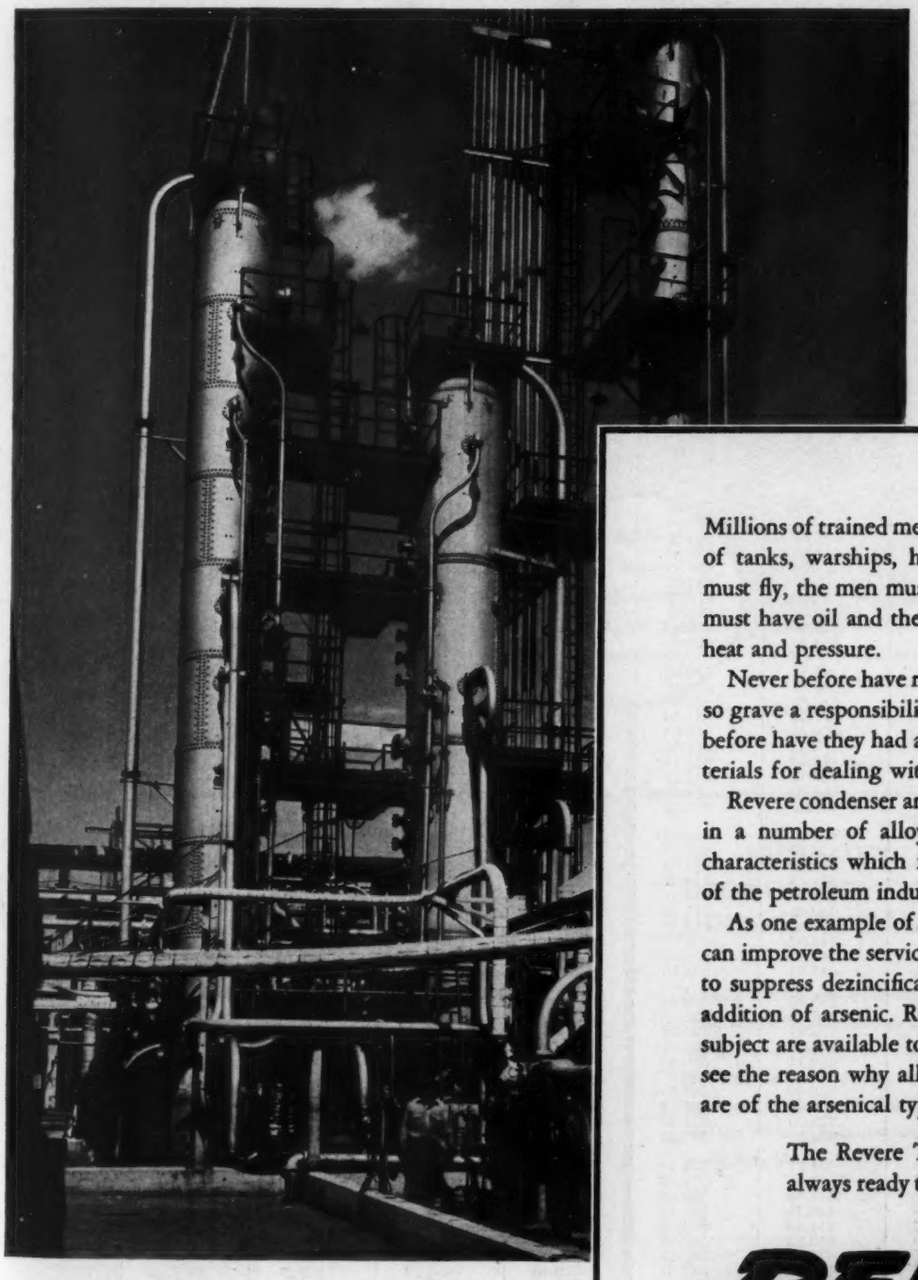


IT TAKES OIL TO WIN



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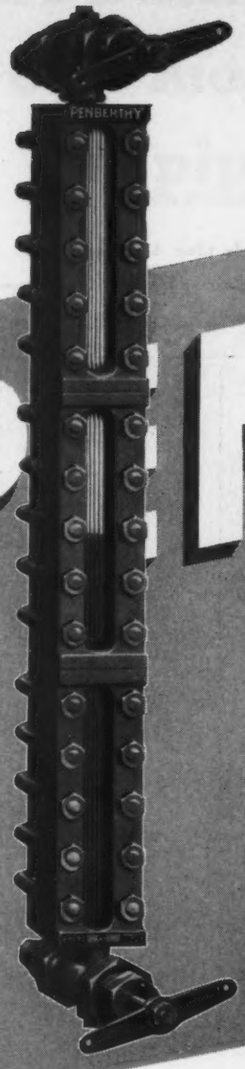
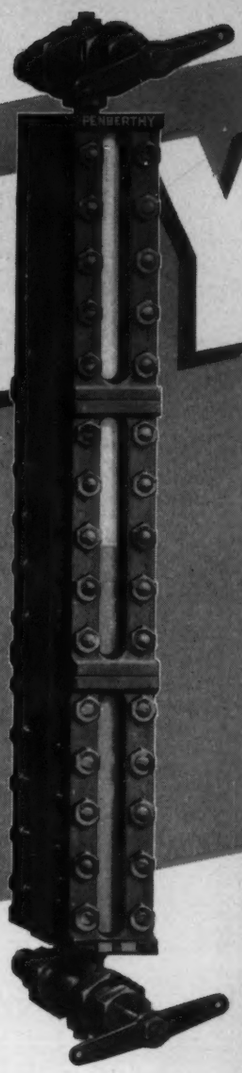
Specific Gravity	FLANGE CONNECTIONS								
	4" x 1"	4" x 1¼"	4" x 1½"	4" x 1¾"	4" x 2"	4" x 2¼"	4" x 2½"	4" x 2¾"	4" x 3"
0.55	277.71	433.92	624.84	851.55	1128.08	1470.17	1895.01	2423.16	3078.47
0.56	275.22	430.03	619.23	843.91	1117.96	1456.97	1878.01	2401.41	3050.84
0.57	272.79	426.23	613.76	836.46	1108.08	1444.11	1831.42	2380.21	3023.90
0.58	270.44	422.56	608.48	829.26	1098.55	1431.68	1845.40	2359.72	2997.88
0.59	268.13	418.96	603.29	822.18	1089.18	1419.47	1829.60	2339.59	2972.31
0.60	265.89	415.45	598.24	815.30	1080.06	1407.58	1814.34	2320.00	2947.42
0.61	263.70	412.04	593.32	808.61	1071.19	1396.03	1799.45	2300.96	2923.22
0.62	261.56	408.69	588.51	802.04	1062.49	1384.69	1784.83	2282.27	2899.48
0.63	259.48	405.44	583.83	795.66	1054.04	1373.67	1770.64	2264.12	2876.42
0.64	257.44	402.26	579.24	789.41	1045.76	1362.88	1756.72	2246.33	2853.82
0.65	255.45	399.14	574.74	783.28	1037.64	1352.30	1743.09	2228.89	2831.67
0.66	253.51	396.11	570.39	777.35	1029.78	1342.06	1729.88	2212.00	2810.21
0.67	251.62	393.15	566.12	771.54	1022.08	1332.02	1716.95	2195.47	2789.20
0.68	249.76	390.26	561.95	765.85	1014.55	1322.21	1704.30	2179.29	2768.66
0.69	247.95	387.42	557.88	760.30	1007.19	1312.62	1691.93	2163.48	2748.57
0.70	246.16	384.62	553.84	754.80	999.91	1303.13	1679.71	2147.85	2728.70
0.71	244.43	381.92	549.95	749.50	992.88	1293.97	1667.90	2132.75	2709.53
0.72	242.72	379.25	546.11	744.25	985.94	1284.82	1656.24	2117.84	2690.58
0.73	241.05	376.64	542.35	739.14	979.16	1276.09	1644.85	2103.28	2672.08
0.74	239.42	374.10	538.69	734.15	972.55	1267.48	1633.75	2089.08	2654.05
0.75	237.82	371.59	535.08	729.22	966.03	1258.97	1622.79	2075.07	2636.24
0.76	236.25	369.14	531.55	724.42	959.67	1250.69	1612.11	2061.41	2618.89
0.77	234.71	366.73	528.08	719.69	953.40	1242.51	1601.57	2047.93	2601.77
0.78	233.20	364.38	524.70	715.08	947.29	1234.55	1591.31	2034.81	2585.10
0.79	231.72	362.07	521.36	710.53	941.27	1226.70	1581.19	2021.87	2568.66
0.80	230.26	359.78	518.07	706.05	935.33	1218.96	1571.21	2009.11	2552.45
0.81	228.84	357.56	514.87	701.69	929.55	1211.44	1561.52	1996.71	2536.70
0.82	227.44	355.37	511.72	697.40	923.86	1204.02	1551.96	1984.49	2521.17
0.83	226.06	353.22	508.62	693.16	918.26	1196.72	1542.54	1972.45	2505.88
0.84	224.72	351.12	505.60	689.06	912.82	1189.63	1533.41	1960.77	2491.04
0.85	223.40	349.06	502.64	685.02	907.47	1182.65	1524.41	1949.27	2476.43
0.86	222.08	347.00	499.67	680.98	902.11	1175.67	1515.42	1937.77	2461.81
0.87	220.80	345.01	496.80	677.06	896.93	1168.91	1506.71	1926.63	2447.66
0.88	219.55	343.05	493.97	673.21	891.82	1162.26	1498.13	1915.67	2433.73
0.89	218.31	341.12	491.19	669.42	886.80	1155.72	1489.70	1904.88	2420.04
0.90	217.10	339.22	488.46	665.69	881.87	1149.29	1481.41	1894.28	2406.57
0.91	215.90	337.35	485.77	662.03	877.01	1142.97	1473.26	1883.86	2393.32
0.92	214.73	335.52	483.13	658.43	872.25	1136.75	1465.25	1873.61	2380.31
0.93	213.58	333.71	480.54	654.89	867.56	1130.65	1457.38	1863.55	2367.52
0.94	212.42	331.91	477.94	651.36	862.88	1124.54	1449.51	1853.49	2354.74
0.95	211.31	330.17	475.44	647.95	858.36	1118.65	1441.92	1843.78	2342.41
0.96	210.20	328.44	472.94	644.54	853.84	1112.76	1434.33	1834.08	2330.08
0.97	209.11	326.73	470.48	641.19	849.41	1106.99	1426.88	1824.56	2317.98
0.98	208.06	325.09	468.12	637.97	845.14	1101.43	1419.71	1815.39	2305.34
0.99	206.98	323.42	465.70	634.68	840.79	1195.76	1412.40	1805.05	2294.47
1.00	205.96	321.81	463.39	631.53	836.61	1090.30	1405.38	1797.06	2283.05
1.01	204.93	320.20	461.07	628.37	832.42	1084.85	1398.35	1788.07	2271.64
1.02	203.92	318.62	458.80	625.27	828.32	1079.51	1391.46	1779.27	2260.45
1.03	202.93	317.08	456.58	622.24	824.31	1074.28	1384.72	1770.64	2249.49
1.04	201.96	315.56	454.40	619.27	820.38	1069.15	1378.11	1762.20	2238.76
1.05	200.99	314.05	452.22	616.31	816.44	1064.03	1371.51	1753.75	2228.03
1.06	200.04	312.57	450.09	613.40	812.60	1059.01	1365.04	1745.48	2217.53
1.07	199.09	311.09	447.96	610.50	808.75	1054.00	1358.58	1737.22	2207.03
1.08	198.19	309.67	445.92	607.72	805.07	1049.20	1352.40	1729.31	2196.98
1.09	197.26	308.23	443.83	604.88	801.30	1044.29	1346.07	1721.22	2186.71
1.10	196.38	306.84	441.84	602.16	797.70	1039.60	1340.03	1713.50	2176.89
1.11	195.49	305.46	439.85	599.44	794.27	1034.92	1333.98	1705.77	2167.07
1.12	194.61	304.08	437.86	596.73	790.51	1030.23	1327.94	1698.04	2157.26
1.13	193.74	302.72	435.91	594.08	787.00	1025.65	1322.04	1690.49	2147.67
1.14	192.90	301.40	434.01	591.49	783.57	1021.18	1316.28	1683.13	2138.31
1.15	192.05	300.09	432.11	588.90	780.14	1016.71	1310.51	1675.76	2128.95
1.16	191.23	298.80	430.26	586.37	776.79	1012.35	1304.89	1668.57	2119.81
1.17	190.41	297.51	428.40	583.85	773.44	1007.99	1299.27	1661.38	2110.68
1.18	189.60	296.26	426.60	581.38	770.18	1003.73	1293.79	1654.37	2101.78
1.19	188.80	295.00	424.79	578.92	766.92	999.48	1288.31	1647.36	2092.87
1.20	188.02	293.78	423.03	576.52	763.74	995.34	1282.97	1640.54	2084.20
1.21	187.23	292.55	421.27	574.12	760.56	991.20	1277.63	1633.71	2075.52
1.22	186.47	291.36	419.55	571.78	757.46	987.16	1272.43	1627.06	2067.08
1.23	185.71	290.17	417.84	569.45	754.37	983.13	1267.23	1620.41	2058.63
1.24	184.95	288.98	416.12	567.11	751.27	979.09	1262.03	1613.76	2050.18
1.25	184.21	287.82	414.46	564.84	748.26	975.17	1256.97	1607.29	2041.96
1.26	183.49	286.70	412.83	562.63	745.33	971.35	1252.05	1601.00	2033.97
1.27	182.76	285.57	411.21	560.42	742.40	967.53	1247.13	1594.71	2025.98
1.28	182.04	284.45	409.59	558.21	739.48	963.72	1242.21	1588.42	2017.99
1.29	181.34	283.35	408.01	556.06	736.63	960.01	1237.44	1582.31	2010.23
1.30	180.64	282.26	406.44	553.91	733.79	956.31	1232.66	1576.20	2002.46
1.31	179.94	281.16	404.86	551.76	730.94	952.60	1227.88	1570.09	1994.70
1.32	179.26	280.10	403.33	549.68	728.18	949.00	1223.24	1564.16	1987.17
1.33	178.58	279.04	401.81	547.60	725.42	945.40	1218.60	1558.23	1979.63
1.34	177.92	278.01	400.32	545.58	722.74	941.91	1214.11	1552.48	1972.33
1.35	177.27	276.98	398.84	543.55	720.07	938.42	1209.61	1546.73	1965.02
1.36	176.61	275.95	397.36	541.53	717.39	934.94	1205.11	1540.98	1957.72
1.37	175.97	274.95	395.92	539.58	714.80	931.56	1200.75	1535.41	1950.64
1.38	175.33	273.95	394.48	537.62	712.20	928.18	1196.40	1529.84	1943.56
1.39	174.69	272.96	393.05	535.66	709.61	924.80	1192.04	1524.27	1936.48
1.40	174.07	271.99	391.66	533.77	707.10	921.52	1187.83	1518.88	1929.64



PENBERTHY *Reflex*
DROP FORGED STEEL
LIQUID LEVEL GAGES

PENBERTHY
DROP FORGED STEEL
Transparent
LIQUID LEVEL GAGES



PENBERTHY LIQUID LEVEL GAGES *meet your requirements*

Liquid shows black—empty space shows white. Preferred wherever liquid level must be easily and positively visible . . . and when liquids are under high pressure or at high temperature.

All Penberthy Gages conform with A. P. I.—A. S. M. E. requirements.

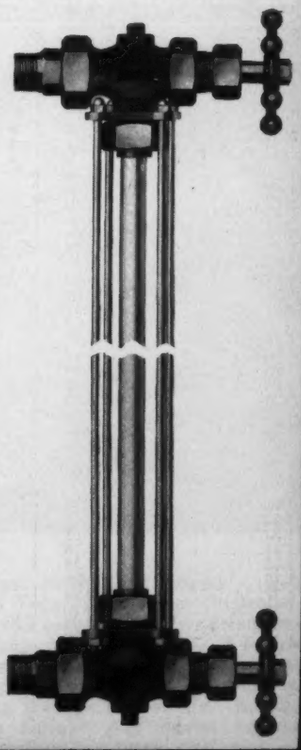
Used to observe color and density of liquids under high pressures, and/or temperatures. Construction is exceptionally rugged . . . similar to Reflex types.

PENBERTHY *Reflex*
WATER GAGE SET

Water shows black—steam shows white. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.

PENBERTHY
DROP FORGED STEEL
LIQUID LEVEL GAGES

Made of Chromium-molybdenum alloy temperature-resisting steel, extra heavy throughout. Stainless steel trimmed. Tubular glass type gages also available in various other metals suitable for practically all conditions.



PENBERTHY INJECTOR CO.

DETROIT, MICHIGAN • Canadian Plant; Windsor, Ontario

THESE PENBERTHY PRODUCTS

Hourly Orifice Meter Coefficients for Six-Inch Plates

Flowing Temperature, 60° F. Temperature Base, 60° F. Pressure Base, 14.4 pounds plus 4 ounces.

	FLANGE CONNECTIONS								
Specific Gravity	**6" x 2"**	**6" x 2¼"**	**6" x 2½"**	**6" x 2¾"**	**6" x 3"**	**6" x 3¼"**	**6" x 3½"**	**6" x 3¾"**	**6" x 4"**
0.55	1110.02	1405.91	1735.67	2108.32	2536.31	3029.14	3597.82	4254.78	5013.97
0.56	1100.06	1393.30	1720.09	2089.41	2513.55	3001.96	3565.53	4216.60	4968.97
0.57	1090.35	1380.99	1704.91	2070.96	2491.35	2975.45	3534.05	4179.36	4925.10
0.58	1080.96	1369.11	1690.23	2053.13	2469.91	2949.84	3503.63	4143.39	4882.71
0.59	1071.74	1357.43	1675.81	2035.62	2448.84	2924.63	3473.75	4108.05	4841.06
0.60	1062.77	1346.06	1661.78	2018.58	2428.34	2900.20	3444.66	4073.66	4800.53
0.61	1054.05	1335.01	1648.14	2002.00	2408.40	2876.38	3416.38	4040.21	4761.11
0.62	1045.48	1324.17	1634.75	1985.74	2388.84	2853.02	3388.63	4007.39	4722.44
0.63	1037.17	1313.64	1621.75	1969.95	2369.84	2830.33	3361.68	3975.52	4684.88
0.64	1029.02	1303.32	1609.01	1954.47	2351.22	2808.09	3335.27	3944.28	4648.07
0.65	1021.03	1293.20	1596.52	1939.30	2332.97	2786.30	3309.38	3913.68	4612.00
0.66	1013.30	1283.40	1584.42	1924.60	2315.29	2765.18	3284.30	3884.02	4577.05
0.67	1005.72	1273.81	1572.58	1910.22	2297.99	2744.51	3259.75	3854.99	4542.84
0.68	998.31	1264.42	1561.00	1896.15	2281.06	2724.30	3235.74	3826.59	4509.37
0.69	991.07	1255.25	1549.67	1882.39	2264.51	2704.53	3212.26	3798.82	4476.65
0.70	983.91	1246.18	1538.47	1868.78	2248.14	2684.98	3189.05	3771.37	4442.30
0.71	976.99	1237.42	1527.66	1855.65	2232.34	2666.11	3166.63	3744.86	4413.06
0.72	970.16	1228.77	1516.97	1842.67	2216.73	2647.47	3144.49	3718.67	4382.20
0.73	963.49	1220.32	1506.55	1830.01	2201.49	2629.27	3122.88	3693.11	4352.08
0.74	956.99	1212.08	1496.38	1817.66	2186.63	2611.52	3101.80	3668.18	4322.71
0.75	950.57	1203.95	1486.34	1805.46	2171.96	2594.00	3080.98	3643.57	4293.70
0.76	944.31	1196.03	1476.56	1793.58	2157.67	2576.93	3060.71	3619.59	4265.44
0.77	938.14	1188.21	1466.90	1781.85	2143.56	2560.08	3040.69	3595.92	4237.55
0.78	932.13	1180.59	1457.50	1770.44	2129.83	2543.68	3021.22	3572.89	4210.41
0.79	926.20	1173.09	1448.24	1759.18	2116.28	2527.51	3002.01	3550.17	4183.64
0.80	920.36	1165.68	1439.10	1748.08	2102.93	2511.56	2983.06	3527.77	4157.23
0.81	914.68	1158.39	1430.09	1737.29	2089.95	2496.06	2964.65	3505.99	4131.58
0.82	909.08	1151.40	1421.46	1726.66	2077.16	2480.78	2946.51	3484.54	4106.29
0.83	903.56	1144.41	1412.84	1716.18	2064.56	2465.73	2928.63	3463.40	4081.38
0.84	898.21	1137.64	1404.47	1706.02	2052.33	2451.13	2911.29	3442.89	4057.21
0.85	892.94	1130.96	1396.23	1696.01	2040.29	2436.75	2894.21	3422.69	4033.41
0.86	887.67	1124.29	1388.00	1686.00	2029.26	2422.37	2877.13	3402.50	4009.61
0.87	882.57	1117.83	1380.01	1676.31	2016.59	2408.44	2860.59	3382.93	3986.56
0.88	877.54	1111.47	1372.16	1666.77	2005.12	2396.09	2844.31	3363.69	3963.88
0.89	872.61	1105.21	1364.44	1657.39	1993.83	2381.26	2828.30	3344.75	3941.56
0.90	867.75	1099.06	1356.84	1648.16	1982.72	2368.01	2812.56	3326.14	3919.63
0.91	862.98	1093.01	1349.38	1639.10	1971.83	2354.98	2797.09	3307.83	3898.06
0.92	858.29	1087.07	1342.04	1630.18	1961.10	2342.17	2781.88	3289.85	3876.86
0.93	853.67	1081.23	1334.83	1621.43	1950.57	2329.59	2766.94	3272.18	3856.04
0.94	849.06	1075.39	1327.63	1612.67	1940.04	2317.01	2751.99	3254.51	3835.22
0.95	844.62	1069.76	1320.67	1604.23	1929.88	2304.88	2737.59	3237.47	3815.14
0.96	840.17	1064.13	1313.72	1595.78	1919.72	2292.78	2723.18	3220.43	3795.06
0.97	835.81	1058.60	1306.90	1587.50	1909.75	2280.84	2709.04	3203.71	3775.35
0.98	831.61	1053.29	1300.34	1579.52	1900.16	2269.39	2695.43	3187.61	3756.39
0.99	827.33	1047.87	1293.64	1571.39	1890.38	2257.70	2681.55	3117.20	3737.05
1.00	823.22	1042.65	1287.21	1563.58	1880.98	2246.47	2668.21	3155.43	3718.46
1.01	819.10	1037.44	1280.77	1555.76	1871.57	2235.24	2654.87	3139.65	3699.86
1.02	815.07	1032.33	1274.76	1548.10	1862.35	2224.46	2649.80	3124.19	3681.64
1.03	811.11	1027.33	1268.29	1540.59	1853.32	2213.45	2628.99	3109.04	3663.80
1.04	807.25	1022.42	1262.24	1533.24	1844.48	2202.89	2616.45	3094.21	3646.32
1.05	803.38	1017.52	1256.19	1525.89	1835.64	2192.33	2603.91	3079.38	3628.84
1.06	799.59	1012.73	1250.26	1518.70	1826.99	2182.00	2591.63	3064.87	3611.74
1.07	795.80	1007.93	1244.34	1511.51	1818.34	2171.66	2579.36	3050.35	3594.63
1.08	793.18	1003.34	1238.68	1504.63	1810.06	2161.78	2567.62	3036.47	3578.27
1.09	788.48	998.65	1232.89	1497.59	1801.60	2151.67	2555.61	3022.27	3561.54
1.10	784.94	994.17	1227.35	1490.87	1793.51	2142.01	2544.14	3008.70	3545.55
1.11	781.40	989.69	1221.82	1484.15	1785.42	2132.35	2532.67	2995.13	3529.55
1.12	777.86	985.20	1216.28	1477.42	1777.33	2122.69	2521.19	2981.56	3513.57
1.13	774.40	980.82	1210.88	1470.86	1769.43	2113.16	2509.99	2968.31	3497.95
1.14	771.02	976.55	1205.60	1464.44	1761.72	2104.05	2499.05	2955.37	3482.71
1.15	767.65	972.27	1200.32	1458.03	1754.01	2094.84	2488.11	2942.44	3467.46
1.16	764.36	968.10	1195.17	1451.78	1746.49	2085.85	2477.43	2929.81	3452.59
1.17	761.06	963.93	1190.02	1445.53	1738.96	2076.86	2466.76	2917.19	3437.71
1.18	757.85	959.87	1185.00	1439.43	1731.63	2068.10	2456.36	2904.89	3423.21
1.19	754.64	955.80	1179.98	1433.33	1724.29	2059.34	2445.95	2892.58	3408.71
1.20	751.51	951.84	1175.09	1427.39	1717.14	2050.80	2435.81	2880.59	3394.58
1.21	748.39	947.87	1170.20	1421.45	1709.99	2042.27	2425.67	2868.60	3380.45
1.22	745.34	944.02	1165.44	1415.66	1703.03	2033.96	2415.80	2856.92	3366.69
1.23	742.29	940.16	1160.67	1409.88	1696.08	2025.64	2405.93	2845.25	3352.93
1.24	739.25	936.30	1155.91	1404.09	1689.12	2017.33	2396.05	2833.57	3339.17
1.25	736.28	932.55	1151.28	1398.46	1682.34	2009.24	2386.45	2822.21	3325.79
1.26	733.40	928.90	1146.77	1392.99	1675.76	2001.38	2377.11	2811.17	3312.77
1.27	730.52	925.25	1142.27	1387.52	1669.18	1993.52	2367.77	2800.13	3299.76
1.28	727.64	921.60	1137.76	1382.04	1662.59	1985.66	2358.43	2789.08	3286.74
1.29	724.84	918.06	1133.39	1376.73	1656.20	1978.02	2349.36	2778.35	3274.10
1.30	722.04	914.51	1129.01	1371.41	1649.80	1970.38	2340.29	2767.63	3261.46
1.31	719.24	910.97	1124.63	1366.10	1643.41	1962.74	2331.22	2756.90	3248.82
1.32	716.53	907.52	1120.38	1360.94	1637.20	1955.33	2322.41	2746.48	3236.54
1.33	713.81	904.08	1116.14	1355.78	1630.99	1947.92	2313.61	2736.07	3224.27
1.34	711.18	900.75	1112.02	1350.77	1624.97	1940.73	2305.07	2725.97	3212.38
1.35	708.54	897.41	1107.90	1345.77	1618.96	1933.54	2296.53	2715.88	3200.48
1.36	705.91	894.07	1103.78	1340.77	1612.94	1926.35	2287.99	2705.78	3188.58
1.37	703.36	890.84	1099.79	1335.92	1607.11	1919.39	2279.72	2696.00	3177.05
1.38	700.20	887.61	1095.80	1331.07	1601.27	1912.42	2271.45	2686.22	3165.52
1.39	698.25	884.38	1091.81	1326.22	1595.44	1905.46	2263.18	2676.43	3154.00
1.40	695.78	881.25	1087.95	1321.53	1589.80	1898.72	2255.17	2666.97	3142.84

Crowding the turns can mean trouble in piping, too!

When they're riding hell-bent for leather . . .

LOOK OUT! Rounding the turn into the stretch is the place where a horse races can be won or lost. A horse gets "pocketed." A rider is jostled. Because there's *added* danger at the turns, anything can happen! TURNS are crucial danger spots in piping systems, too! That's why welding with Tube-Turn fittings is sounder practice wherever pressure and strain are liable to cause leaks, breaks, or pipe connection failures of any kind. There is a Tube-Turn fitting to protect and strengthen *every* piping turn—all types, sizes and weights—returns, elbows, tees, reducers, laterals, nipples, caps, saddles, and flanges.

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Welding Fittings

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In this compact, streamlined assembly, welded pipe lines and Tube-Turn fittings *(indicated by check marks)* will harness wild, live steam in one of America's large industrial plants. A failure at any point here would mean more than stopped production and lost man hours. It could mean terrific damage, perhaps loss of life. But Tube-Turn welding fittings give *added protection* where it's needed—at the turns!

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Flowing Temperature, 60° F. Temperature Base, 60° F. Pressure Base, 14.4 pounds plus 4 ounces.

Specific Gravity	FLANGE CONNECTIONS								
	8" x 4"	8" x 4¼"	8" x 4½"	8" x 4¾"	8" x 5"	8" x 5¼"	8" x 5½"	8" x 5¾"	8" x 6"
0.55	4519.54	5171.39	5898.08	6708.92	7613.86	8623.92	9750.82	11,007.18	12,406.54
0.56	4478.98	5124.99	5845.15	6648.72	7645.54	8546.53	9663.32	10,908.40	12,295.21
0.57	4439.43	5079.73	5793.54	6590.01	7578.91	8471.06	9577.99	10,812.08	12,186.64
0.58	4401.22	5036.01	5743.67	6533.29	7514.54	8398.15	9495.55	10,719.02	12,081.75
0.59	4363.68	4993.06	5694.68	6477.56	7451.29	8326.52	9414.56	10,627.59	11,978.70
0.60	4327.15	4951.25	5647.01	6423.33	7389.75	8256.80	9335.74	10,538.61	11,878.41
0.61	4291.62	4910.60	5600.64	6370.59	7329.89	8189.01	9259.08	10,452.08	11,780.88
0.62	4256.76	4870.71	5555.15	6318.84	7271.17	8122.50	9183.88	10,367.19	11,685.19
0.67	4222.91	4831.98	5510.97	6268.59	7214.14	8057.90	9110.84	10,284.74	11,592.26
0.64	4189.73	4794.01	5467.67	6219.33	7058.24	7994.58	9039.25	10,203.93	11,501.17
0.65	4157.21	4756.81	5425.24	6171.07	7003.46	7932.54	8969.11	10,124.74	11,411.92
0.66	4125.71	4720.76	5384.12	6124.30	6950.39	7872.43	8901.13	10,048.01	11,325.43
0.67	4094.87	4685.47	5343.88	6078.53	6898.44	7813.59	8834.60	9972.91	11,240.78
0.68	4064.70	4650.96	5304.51	6033.75	6847.62	7756.02	8769.52	9899.44	11,157.97
0.69	4035.21	4617.21	5266.02	5989.96	6797.93	7699.74	8705.88	9827.60	11,077.00
0.70	4006.05	4583.84	5227.96	5946.68	6748.80	7644.10	8642.97	9756.58	10,996.96
0.71	3977.89	4551.62	5191.22	5904.88	6701.37	7590.38	8582.23	9688.01	10,919.67
0.72	3950.07	4519.79	5154.92	5863.59	6654.51	7537.29	8522.20	9620.26	10,843.30
0.73	3922.92	4488.73	5119.49	5823.28	6608.77	7485.49	8463.63	9554.14	10,768.77
0.74	3896.44	4458.43	5084.93	5783.98	6564.16	7434.96	8406.50	9489.65	10,696.09
0.75	3870.30	4428.51	5050.81	5745.17	6520.12	7385.08	8350.10	9425.98	10,624.32
0.76	3844.83	4419.37	5017.57	5707.36	6477.20	7336.47	8295.14	9363.94	10,554.39
0.77	3819.69	4370.60	4984.76	5670.04	6434.85	7288.50	8240.90	9302.71	10,485.38
0.78	3795.22	4342.60	4952.83	5633.72	6393.63	7241.81	8188.11	9243.12	10,418.22
0.79	3771.09	4314.99	4921.34	5597.90	6352.98	7195.76	8136.05	9184.35	10,351.97
0.80	3747.29	4287.76	4890.28	5562.57	6312.89	7150.35	8084.71	9126.39	10,286.64
0.81	3724.16	4261.30	4860.10	5528.24	6273.93	7106.22	8034.81	9070.06	10,223.16
0.82	3701.37	4235.22	4830.36	5494.41	6235.53	7062.73	7985.64	9014.56	10,160.59
0.83	3678.91	4209.52	4801.05	5461.07	6197.70	7019.88	7937.18	8959.86	10,098.95
0.84	3657.13	4184.59	4772.62	5428.73	6160.99	6978.31	7890.18	8906.80	10,039.14
0.85	3635.68	4160.05	4744.62	5396.89	6124.86	6937.38	7843.90	8854.56	9980.25
0.86	3614.23	4135.50	4716.63	5365.05	6088.72	6896.45	7797.62	8802.31	9921.37
0.87	3593.44	4111.73	4689.51	5334.20	6053.71	6856.79	7752.78	8751.70	9864.32
0.88	3573.00	4088.33	4662.83	5303.85	6019.26	6817.78	7708.67	8701.91	9808.20
0.89	3552.89	4065.32	4636.58	5274.00	5985.38	6779.41	7665.28	8652.93	9752.99
0.90	3533.11	4042.69	4610.77	5244.64	5952.07	6741.67	7622.62	8604.77	9698.70
0.91	3513.67	4020.45	4585.40	5215.78	5919.32	6704.58	7580.68	8557.42	9645.34
0.92	3494.57	3998.59	4560.47	5187.42	5887.13	6668.12	7539.46	8510.89	9592.89
0.93	3475.80	3977.11	4535.96	5159.56	5855.51	6632.31	7498.96	8465.18	9541.37
0.94	3457.03	3955.63	4511.48	5131.70	5823.89	6596.49	7458.47	8419.46	9489.84
0.95	3438.93	3934.92	4487.86	5104.83	5793.40	6561.95	7419.42	8375.38	9440.16
0.96	3420.83	3914.21	4464.24	5077.96	5762.91	6527.42	7380.37	8331.30	9390.47
0.97	3403.06	3893.89	4441.06	5051.59	5732.98	6493.52	7373.42	8288.04	9341.71
0.98	3385.97	3874.33	4418.75	5026.22	5704.18	6460.90	7305.16	8246.40	9294.78
0.99	3368.54	3854.38	4396.00	5000.34	5674.82	6427.64	7267.56	8203.96	9246.94
1.00	3351.78	3835.21	4374.13	4975.47	5646.59	6395.67	7231.40	8163.14	9200.93
1.01	3335.02	3816.03	4352.26	4950.59	5618.36	6363.69	7195.24	8122.32	9154.93
1.02	3318.60	3797.24	4330.83	4926.21	5590.69	6332.35	7159.81	8082.32	9109.84
1.03	3302.51	3778.83	4309.83	4902.33	5563.58	6301.65	7125.10	8043.14	9065.68
1.04	3286.76	3760.80	4289.27	4878.94	5537.05	6271.59	7091.11	8004.78	9022.44
1.05	3271.00	3742.78	4268.72	4855.56	5510.51	6241.53	7057.12	7956.41	8979.19
1.06	3255.58	3725.14	4248.60	4832.67	5484.53	6212.11	7023.86	7928.86	8936.87
1.07	3240.17	3707.49	4228.47	4809.78	5458.56	6182.69	6990.59	7891.31	8894.54
1.08	3225.42	3690.62	4209.23	4787.89	5433.71	6154.55	6958.78	7855.39	8854.06
1.09	3210.34	3673.36	4189.54	4775.45	5408.30	6125.77	6926.23	7818.66	8812.65
1.10	3195.92	3656.87	4170.74	4744.11	5384.02	6098.27	6895.14	7783.55	8773.09
1.11	3181.51	3640.38	4151.93	4722.71	5359.74	6070.77	6864.04	7748.45	8733.53
1.12	3167.10	3623.89	4133.12	4701.32	5335.46	6043.26	6832.95	7713.35	8693.96
1.13	3153.02	3607.78	4114.75	4680.42	5311.75	6016.40	6802.58	7679.07	8655.32
1.14	3139.28	3592.05	4096.81	4660.02	5288.60	5990.18	6772.93	7645.60	8617.59
1.15	3125.54	3576.33	4078.88	4639.62	5265.44	5963.96	6743.28	7612.13	8579.87
1.16	3112.13	3560.99	4061.38	4619.72	5242.86	5938.38	6714.35	7579.48	8543.07
1.17	3098.72	3545.65	4043.89	4599.82	5220.27	5912.79	6685.43	7546.82	8506.26
1.18	3085.65	3530.69	4026.83	4580.41	5198.25	5887.85	6657.23	7514.99	8470.38
1.19	3072.58	3515.73	4009.77	4561.01	5176.23	5862.91	6629.02	7483.15	8434.50
1.20	3059.84	3501.16	3993.15	4542.10	5154.77	5838.60	6601.55	7452.13	8399.53
1.21	3047.10	3486.59	3976.52	4523.20	5133.31	5814.30	6574.07	7421.11	8364.57
1.22	3034.70	3472.40	3960.34	4504.79	5112.42	5790.64	6547.31	7390.91	8330.53
1.23	3022.30	3458.21	3944.16	4486.38	5091.53	5766.97	6520.55	7360.70	8296.48
1.24	3009.90	3444.02	3927.97	4467.97	5070.64	5743.31	6493.80	7330.50	8262.44
1.25	2997.83	3430.21	3912.22	4450.06	5050.31	5720.28	6467.76	7301.11	8229.32
1.26	2986.10	3416.79	3896.92	4432.64	5030.55	5697.90	6442.45	7272.54	8197.11
1.27	2974.37	3403.36	3881.61	4415.23	5010.78	5675.51	6417.14	7243.97	8164.91
1.28	2962.64	3389.94	3866.30	4397.82	4991.02	5653.13	6391.83	7215.40	8132.71
1.29	2951.24	3376.90	3851.42	4380.90	4971.82	5631.38	6367.25	7187.64	8101.42
1.30	2939.85	3363.86	3836.55	4363.98	4952.62	5609.64	6342.66	7159.89	8070.14
1.31	2928.45	3350.82	3821.68	4347.07	4933.42	5587.89	6318.07	7132.14	8038.86
1.32	2917.39	3338.16	3807.25	4330.65	4914.79	5566.79	6294.21	7105.20	8008.49
1.33	2906.33	3325.51	3792.81	4314.23	4896.16	5545.68	6270.35	7078.26	7978.13
1.34	2895.60	3313.24	3778.81	4298.31	4878.09	5525.22	6247.21	7052.14	7948.69
1.35	2884.88	3300.96	3764.82	4282.38	4860.02	5504.75	6224.07	7026.01	7919.24
1.36	2874.15	3288.69	3750.82	4266.46	4841.95	5484.28	6200.93	6999.89	7889.80
1.37	2863.76	3276.80	3737.26	4251.04	4824.45	5464.46	6178.51	6974.59	7861.28
1.38	2853.37	3264.91	3723.70	4235.62	4806.94	5444.63	6156.09	6949.28	7832.76
1.39	2842.98	3253.02	3710.14	4220.19	4789.44	5424.80	6133.67	6923.98	7804.23
1.40	2832.93	3241.52	3697.02	4205.26	4772.50	5405.62	6111.98	6899.49	7776.63

HEAT TRANSFER TAKES PLACE IN SECONDS

CONTINUOUS, RAPID FLOW OF PRODUCT

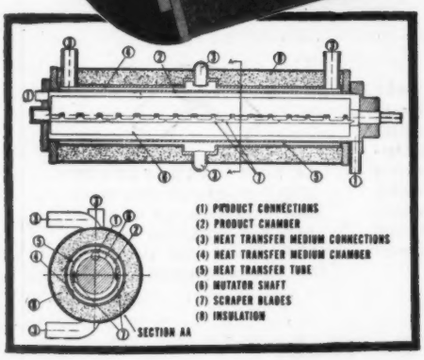
UNIFORM TEMPERATURE ACCURATELY CONTROLLED

FULLY CLOSED SYSTEM

SIMULTANEOUS MIXING, EMULSIFYING OR AERATING

MORE ECONOMICAL

A New Heat Transfer Unit for Liquids and Viscous Materials Offers 6 Big Advantages!



The VOTATOR'S obvious advantages over open systems or batch methods offer new efficiency, speed and economy. While the VOTATOR is new to many industries, it has proved an outstanding success for over ten years as an integral part of complete systems serving certain special fields. VOTATOR units are available in standard sizes and designs that connect easily into virtually any process or system for liquids and viscous materials. The VOTATOR is very simple, easy to clean, and can be adjusted quickly, with immediate results.

The VOTATOR heats or cools instantaneously— by a highly efficient, thoroughly proved method!

The VOTATOR is a unique, continuous, closed heat transfer unit that heats or cools liquids and viscous materials BETTER AND FASTER than any known system. Its extraordinary efficiency is due to the patented principle of passing a very thin film of product over a relatively large heat transfer surface. Heating or cooling takes place in SECONDS instead of minutes. By treating only a small amount of product at any time, but pumping it through continuously at a high rate, the VOTATOR assures very accurate uniform temperatures.

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Conservation of Welding Electrode

TYPE OF JOINT—Proper joint to select is the one which meets service requirements and costs the least. Obviously, if requirements are met by the simpler type of joint, which requires less machining and less electrode, it is a waste of time, labor and materials to use a more complicated type.

BUTT JOINTS

1. PLAIN BUTT JOINT. Largely used on plates up to 3/8" thick with metal electrode, 3/4" with carbon electrode, although generally used below this. Inexpensive as to preparation of joint. Suitable for all usual load conditions if full penetration is secured.

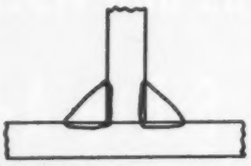
2. SINGLE V BUTT JOINT. Used largely for 3/8" plate or thicker. Scarfing and machining costs more than (1) and more electrode used than in (1). Used generally on plates thicker than in (1). Meets all general or usual load conditions.

3. DOUBLE V BUTT JOINT. The cost of machining is greater but less weld metal is used than in (2). Cost of machining and welding should be balanced against each other. Used largely for 1/2" and heavier, and for all usual loads. (Note that joint is welded from both sides.)

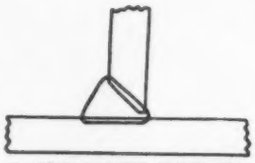
4. SINGLE U BUTT JOINT. Generally used on plates heavier than preceding—1/2", 3/4" and over. Costs more to machine than single V but requires less electrode. Is welded from one side, except a single bead, which is put in last on opposite side. Meets all usual load conditions. Usually used for best quality work.

5. DOUBLE U BUTT JOINT. Used where welds can be made from both sides—in plate sizes usually heavier than in (4) and where the saving in electrode used justifies the greater machining cost as compared to double V. Used in all types of loads.

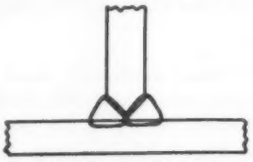
TEE JOINTS



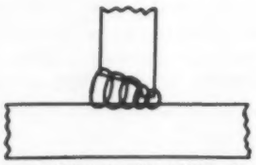
6. PLAIN FILLET WELDED TEE JOINT. May be used for all ordinary plate sizes. No machining of plates. Most satisfactory when welds are in longitudinal shear. For welds heavily loaded transversely by fatigue or severe impact, use with caution.



7. SINGLE V TEE JOINT. This is better than (6). For work welded from one side. Generally used on 1/2" plates or lighter. Costs more for joint preparation but uses less electrode than (6). For more severe load conditions as outlined in (6).



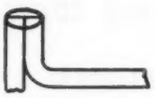
8. DOUBLE V TEE JOINT. Used for heavy plates. Welded from both sides. Uses less electrode than (6). May be used for severe longitudinal or transverse loads of all kinds.



9. SINGLE U TEE JOINT. For usual size plates, generally 1" and heavier. Welded from one side only. Advisable to put in a final finish bead on side away from "U." Machining costs more but takes less electrode than single V. For same load conditions as given under single V (7).

10. DOUBLE U TEE JOINT. For plates generally 1 1/2" and heavier which can be welded from both sides. More expensive preparation but uses less electrode than (8). For all load conditions, even very severe.

EDGE JOINT



16. EDGE JOINT. Generally used for 1/4" or thinner. Not recommended for heavier work. For loads which are not very severe.

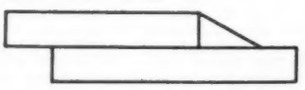
CORNER JOINTS

11. FLUSH CORNER JOINT. Generally used for 12 gauge and lighter. May be used for heavier plates with caution. Not for very severe loads on heavier plate.

12. HALF OPEN CORNER JOINT. Generally used for 12 gauge or heavier, where welded from one side only. "Shouldering" effect reduces probability of burning-through and makes for easy welding. May be used for ordinary loads, but with caution for fatigue or impact loads.

13. FULL OPEN CORNER JOINT. Used for all plate thickness when welds can be made from both sides. May be used under severe load conditions, for maximum strength.

LAP JOINTS



14. SINGLE BEAD LAP JOINT. May be used for all sizes of plates where joints are not subject to excessive fatigue or high impact loads.

15. DOUBLE BEAD LAP JOINT. Better than (14). May be used for load conditions, more severe than single bead lap joint. Beads should be full size, and joints may be loaded much more severely than (14). The butt joint (1-5) is the best joint for very severe service but of course is more expensive.

Courtesy The Lincoln Electric Company

FIGURE 1

Conservation of Welding Electrode Vital to War Effort

CLAYTON B. HERRICK
Welding Engineer, The Lincoln Electric Company, Cleveland, Ohio

THE necessity of conserving materials in the war effort is no where more urgent than in the use of welding.

Welding is the key process which is making possible production of war ships, military planes, tanks and practically all other war equipment at the speeds which are vital to this country's speedy and complete victory.

In order that welding may contribute its utmost potentiality in war production, it is important that welding materials be utilized to maximum advantage. This applies particularly to welding electrodes.

The electrode for welding is probably the most essential piece of war-industry equipment today. It is the electrode which provides the metal of proper physical properties and operating characteristics permitting production of highest quality welds in minimum time and at minimum cost.

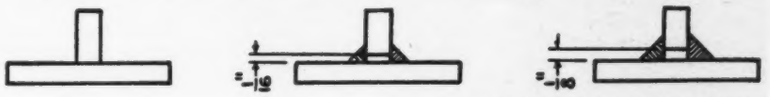
There are a considerable number of factors which affect the most efficient use of electrodes. If conscientiously controlled, these factors will contriute to best use of welding in the war effort. The result will be a still faster rate of production by the use of welding and full utilization of the materials which welding-equipment manufacturers are producing at peak capacity.

The factors which have an important bearing on this situation follow:

1. *Select the Right Type of Joint and Be Careful of Fit-Up.* There is a type of joint (Figure 1) best suited to the particular job. A serious disadvantage in waste of weld metal results by using a complicated joint where the more simple type of connection will suffice. Since the type of joint greatly affects the amount of metal required, it is suggested that a study be made to make sure the joint is proper for the particular applica-

Conservation of Welding Electrode

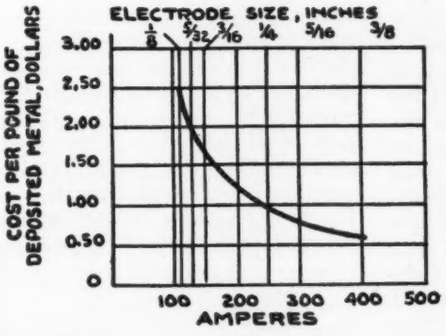
FIT-UP OF JOINT—Improper gap in plates to be joined makes a difference of .18 and .40 pounds of metal per foot of joint respectively for separations of 1/16-inch (at center), and ⅛-inch (at right). With proper fit-up (at left), metal deposited per foot of joint is .40-pound.



Courtesy The Lincoln Electric Company

FIGURE 2

Conservation of Welding Electrode



ELECTRODE SIZE—Effect of electrode size on economy is shown in the chart at left and table below. Note how the cost of welding goes down as electrode size goes up. Note, also, electrode consumption rate, pounds of electrode deposited per hour, number of stub ends (indicated by interruptions per pound consumed), and cost of interruptions to change electrodes.

	Effect of Changing Electrode Size					
Electrode Size	⅛	5/32	3/16	¼	5/16	⅜
Amperes	110	130	150	250	325	425
Arc Volts	24	25	26	30	34	38
K. W. at Arc	2.64	3.25	3.9	7.5	11.1	16.1
Consumption Rate, Lbs. per Hour	2.6	3.3	3.95	7.5	10.7	16.2
Deposit, Lbs. per Hour (50% Operating Factor)	0.87	1.1	1.32	2.5	3.57	5.4
Efficiency of Set (%)	47	50	51	55	59	59
Kilowatt Input	5.6	6.5	7.65	13.65	18.8	27.3
Interruptions, per Lb., Consumed	18	.12	8	5	3	2
	Cost Per Pound Deposited					
Labor	$1.150	$0.909	$0.758	$0.400	$0.280	$0.185
Overhead	1.150	.909	.758	.400	.280	.185
Power	.064	.059	.058	.055	.053	.051
Electrode	.150	.135	.127	.127	.127	.127
Cost of Interruption (including overhead)	.050	.033	.022	.014	.008	.005
	$2.564	$2.045	$1.723	$0.996	$0.748	$0.553

FIGURE 3

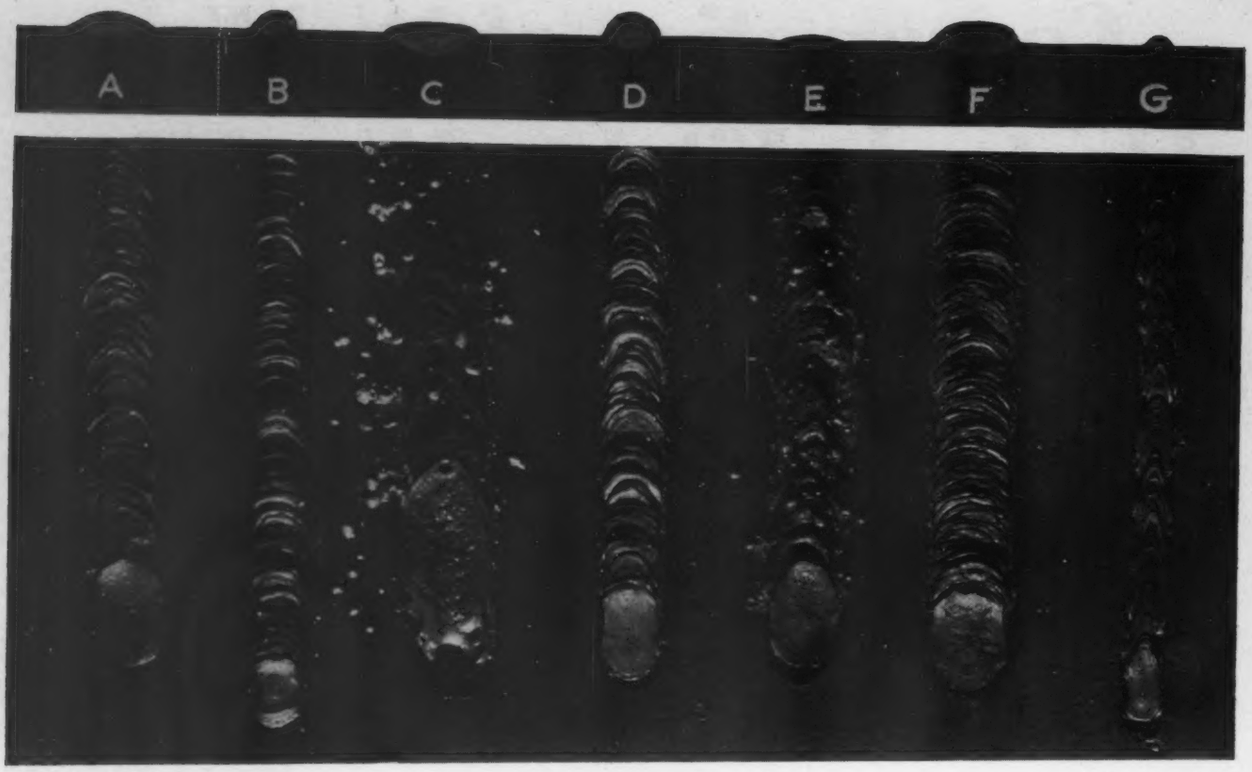


FIGURE 4

Plain and elevation views of welds made with shielded arc electrode under various conditions. (A), current, voltage and speed normal; (B), current too low; (C), current too high; (D), voltage too low; (E), voltage too high; (F), speed too low; (G), speed too high.

tion. Obviously, the joint to select is the one which meets requirements at the greatest speed and the lowest cost.

Joints and their fit-ups should be given most careful consideration, as fit-up affects not only the cost of the welded joint as such, but also the performance of the finished product. As an illustration of the effect upon cost in a very simple fit-up, notice the case shown in Figure 2, where there is shown a T-weld with ¼-inch plates. Assume that the cost of deposited metal is $1.00 per pound. Then if the joint is properly fitted up, the cost per foot of joint (two beads), would be $0.40. If, however, there is a gap between the vertical plate and the horizontal plate of 1/16-inch, the cost is increased to $0.58 per foot. If this discrepancy is ⅛-inch, the cost is increased to $0.80 per foot, resulting in a difference of $0.18 to $0.40 for 1/16th-inch and ⅛-inch respectively. Obviously money spent in obtaining good fit-up is readily saved in welding.

Lbs./Ft. of Joint	.40	.58	.80
Cost/Ft.	$0.40	0.58	0.80
Increase in Cost		$0.18	0.40

2. *Choose the Correct Type of Electrode.* While the general purpose electrode will produce satisfactory welds under virtually every condition, special electrodes as for example heavily coated fast flowing types would prove more efficient. The electrode should be chosen with respect to: (a), physical properties required; (b), type of joint; (c), position of welding, that is, flat, vertical, overhead or horizontal; and (d), condition of fit-up of the work. Recommendations of the equipment manufacturer should be considered.

3. *Use An Electrode Which Has and Maintains a Uniform Coating.* The electrode coating, if not correct, will cause rejects not only of the electrodes themselves but possibly of the welds produced by their use. It should be rememered that the coating not only produces the protecting shield but it also controls: (1), fluidity of the metal; (2), penetration; (3), shape of the beads; (4), physical properties of the deposit; and (5), composition of the deposit.

4. *Use Electrodes Which Provide Proper Physical Properties.* Electrodes manufactured today are clearly described by the manufacturer in respect to the quality of weld they will produce. Required physical properties of the work at hand should be known and the electrode should be selected to meet these requirements.

5. *Use Fast-Flowing Electrodes Wherever Possible.* Certain electrodes are manufactured to permit the fastest possible welding under specified conditions. It is obvious, therefore, that electrode and, hence, time will be saved if these fast-flowing types are used wherever practical.

6. *Select An Electrode Which Keeps Splatter and Slag Loss at a Minimum.* Since all splatter is a waste of weld metal, the importance of this is obvious. It should be realized that the splatter loss of the electrodes vary and care should be taken to avoid use of those which have excessive losses.

7. *Wherever Possible Use Electrodes Which Produce Flat Beads.* It is a waste of welding electrode to deposit any more metal than is required. Not only is the welding electrode itself wasted but useless time is required to remove the excess metal from the welded joint.

8. *Select the Right Size Electrode.* The largest diameter electrode which can be used effectively is the best from the standpoint of electrode con-

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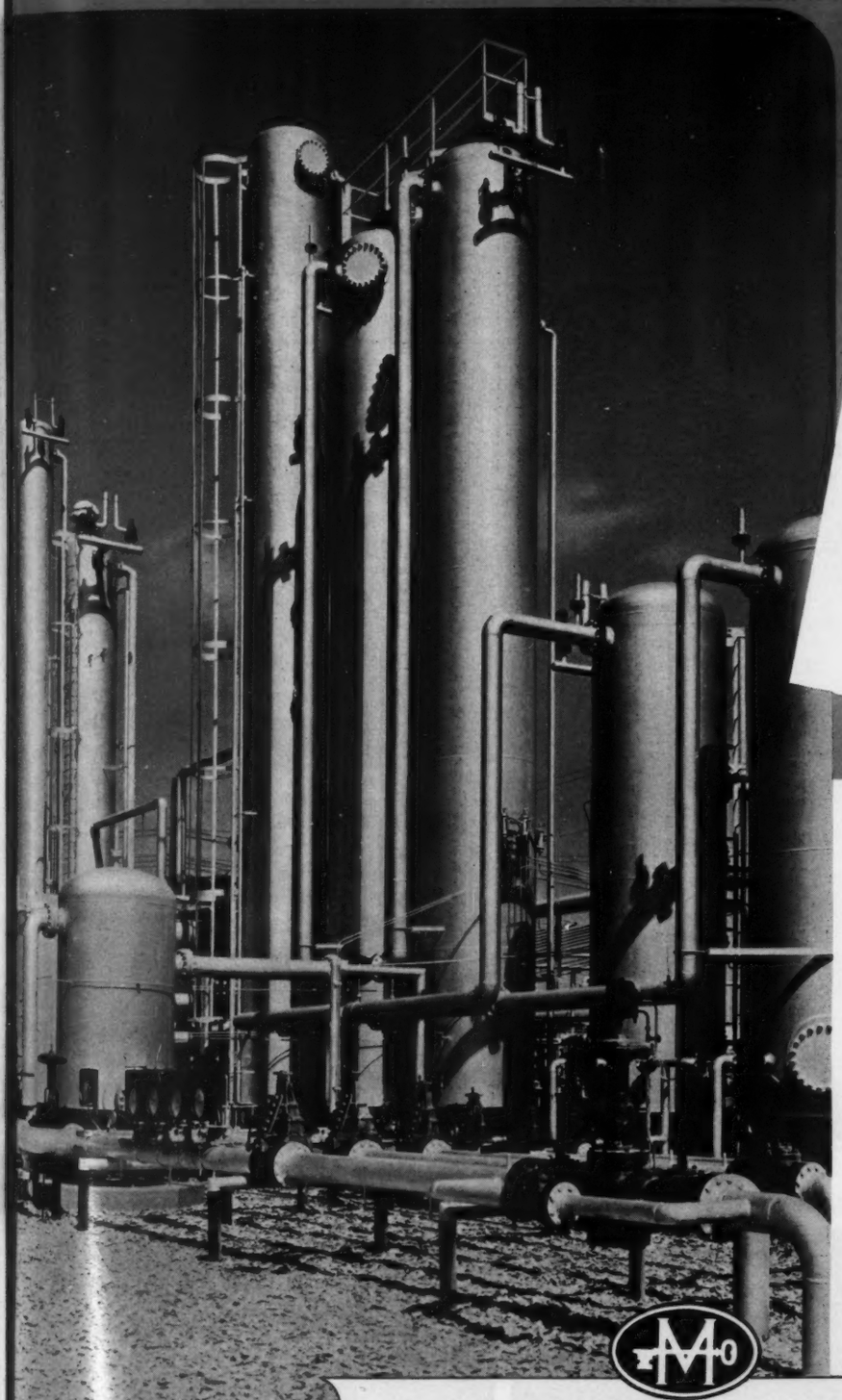

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FIGURE 5

Conservation of Welding Electrode

PROPER PROCEDURE: Characteristics of welds are a good check on electrode conservation. The effect of varying one factor in procedure is indicated below. Note what happens to electrode burn-off rate, weld penetration, appearance of weld and arc sound when the three factors of "arc current," "arc volts" and "arc speed" are varied from "normal."

RESULTING WELD CHARACTERISTICS (SEE FIGURE 6)

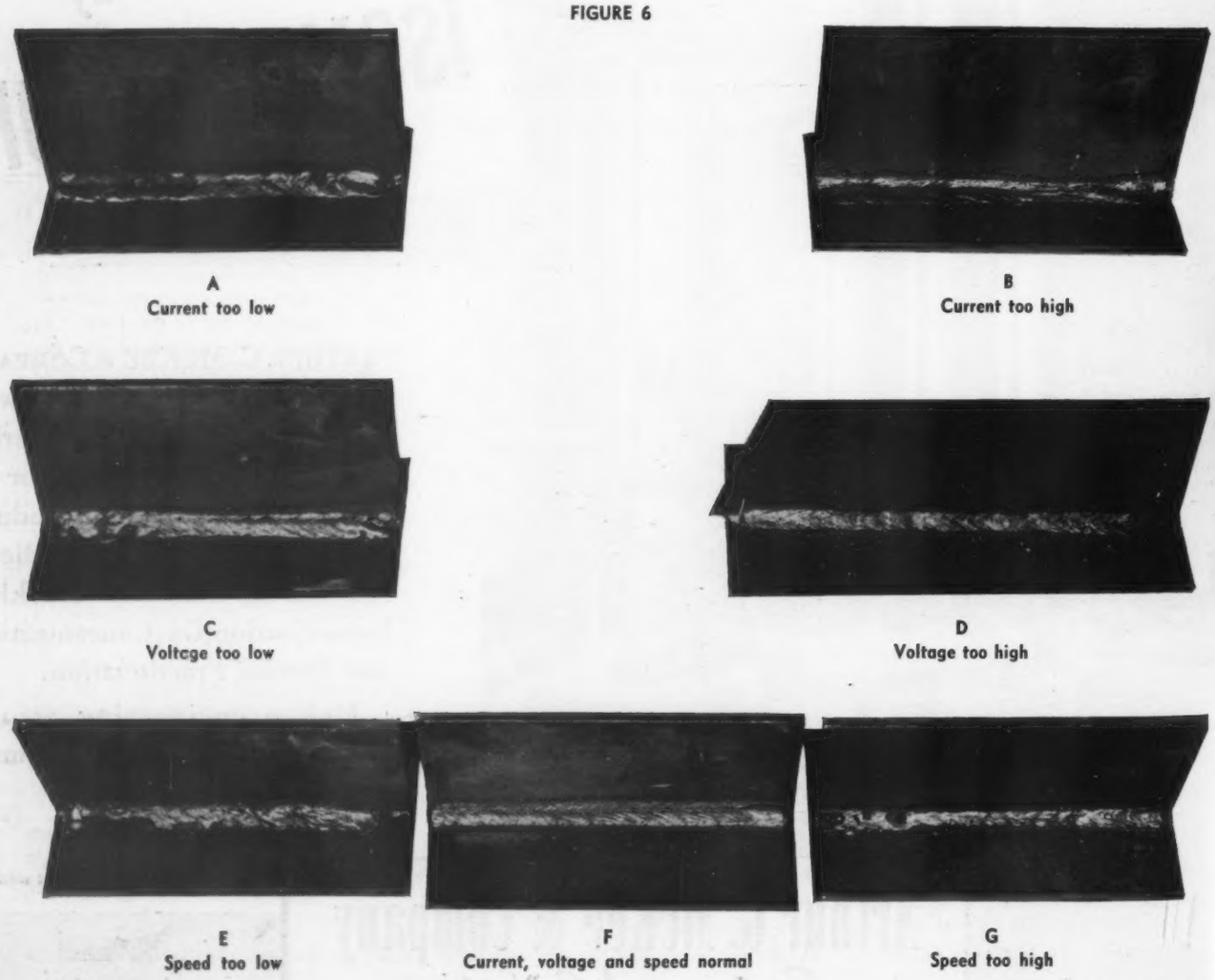
	"F"	"A"	"B"	"C"	"D"	"E"	"G"
Arc current	Normal	Low	High	Normal	Normal	Normal	Normal
Arc volts	Normal	Normal	Normal	Low	High	Normal	Normal
Arc speed	Normal	Normal	Normal	Normal	Normal	Low	High
Burn off of electrode	Normal appearance, coating burns evenly	Practically same as preceding	Coating is consumed at irregular high rate—watch carefully	Coating too close to crater touches molten metal resulting in porosity	Drops at end of electrode flutter and then drop into crater	Normal	Normal
Penetration fusion (crater)	Fairly deep and well defined	Not very deep nor well defined	Deep, long crater	Small	Wide and rather deep	Crater normal	Small, rather well-defined crater
Appearance of bead	Excellent fusion—no overlap	On top of plate, not as much overlap as with bare rod	Broad, thin bead good fusion	High bead not as pronounced as for low amps. somewhat broader	Wide spattered	Wide bead—overlap large. Base metal and bead excessively heated	Small bead—undercut—reduction in bead size and under cutting depends on speed and amperes
Arc sound	Sputtering hiss plus sharp crackling	Irregular sputtering some crackling	Regular explosive sounds	Hiss plus steady sputter	Soft sound plus hiss and few crackles	Normal	Normal

servation. The saving runs up to 40 percent per pound deposited, for example, when ¼-inch is used instead of 3/16-inch. (See Figure 3.)

9. *Use Long Electrodes in the Larger Size.* The obvious result is the reduction in the number of stub ends and in the time saved by eliminating interruptions to change rods. The 18-inch length should be used in ¼-inch and larger sizes.

10. *Do Not Bend Electrodes.* This

FIGURE 6



A
Current too low

B
Current too high

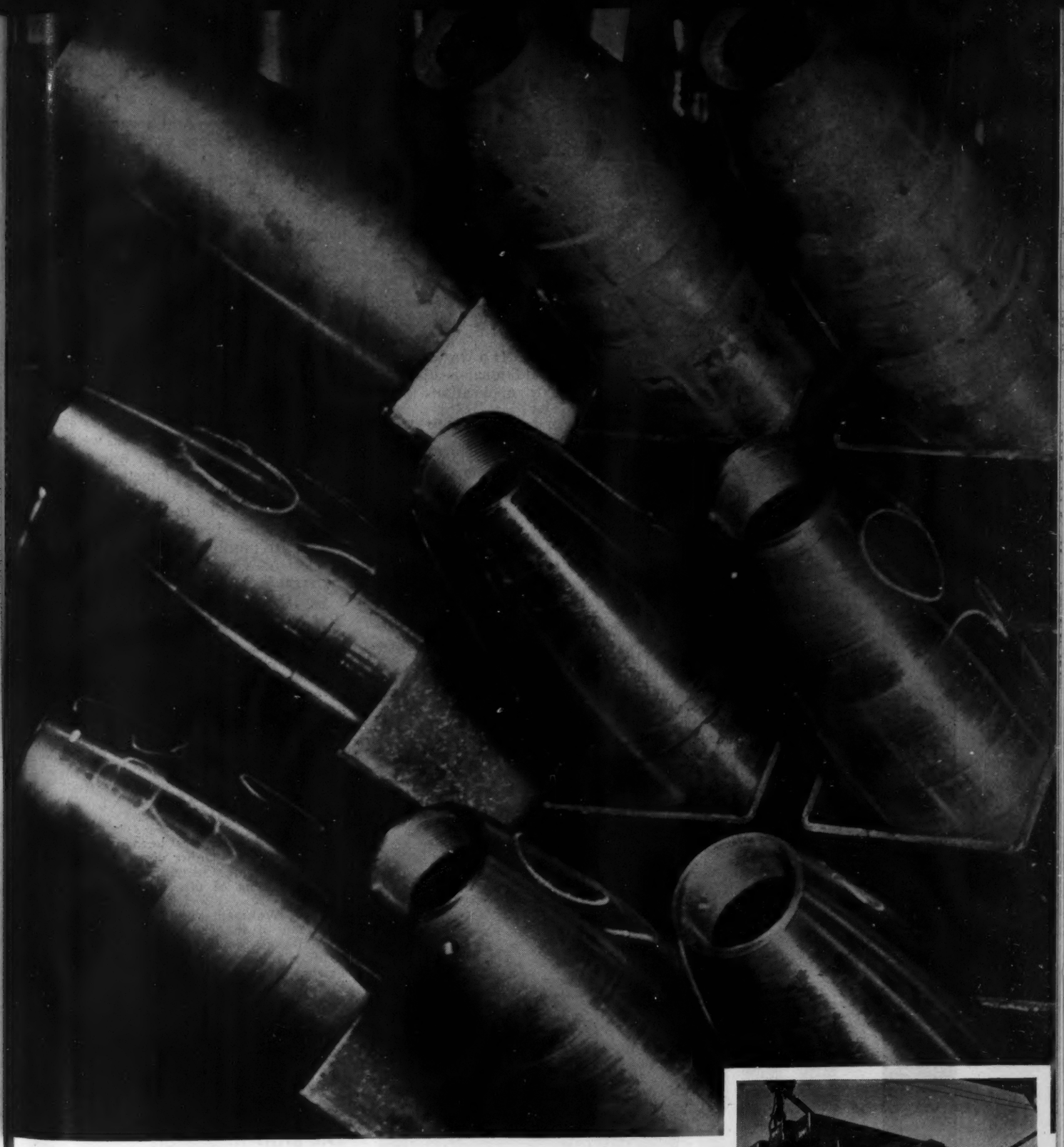
C
Voltage too low

D
Voltage too high

E
Speed too low

F
Current, voltage and speed normal

G
Speed too high



Steel makes history . . . Day and night, Steel is pouring from our ladles, rolling from our mills to be transformed into guns and shells, tanks and trucks, tools and machinery. In every emergency since 1826 we have answered the call to arms. Once again we are working to the limit of our capacity in time of war so that we can serve you better in a free America after the Victory is won.

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generally unnecessary habit will waste from ¼ to 1/3 of the electrode. Use electrodes straight and get the maximum of deposited weld metal from each rod.

11. *Use Proper Voltage and Current Settings.* Every electrode manufactured is designed to operate at a certain voltage and within a specified current range. If current is too high or too low, it will manifest itself either in excessive splatter loss or inferior welds, (Figure 4), having improper fusion and penetration. (Figures 5 and 6).

12. *Follow the Procedure Specified for the Electrode.* Accompanying each different electrode manufactured are detailed specifications regarding procedures to be followed. These specifications have been prepared carefully by the electrode manufacturer and, if followed consistently, will prevent waste of electrode and assure high quality welding.

13. *Avoid Using An Excessive Number of Beads.* If one bead of weld metal will meet design requirements, it is obviously a waste of electrode to add additional beads. This same applies to applications where two beads suffice. Additional beads are simply a useless waste of electrode.

14. *Use Electrode Down to Minimum Stub End.* Remember that the electrode can be used the entire length of its coated surface. Leaving any more than a minimum stub end is an obvious waste. By using care in gripping the electrode at its extreme end in the holder and burning it down to the maximum extent, the operator is rendering a patriotic service in saving electrode. Just ½-inch difference in stub ends saves 3½ percent on an 18-inch length rod.

15. *Collect and Save Stub Ends of Electrode.* At the rate in which welding is being used today in war production, the amount of metal which would be wasted by failure to save stub ends would be tremendous. The average stub end is 2 inches long and this length multiplied by the millions of electrodes used, would constitute the great loss.

16. *Use Modern High Capacity Welding Generator.* Welding generators manufactured today have much higher capacity and much greater efficiency. For example, a modern 40-volt generator was shown to produce 7.7 inches of joint per electrode as against 6.6 inches for an older machine.

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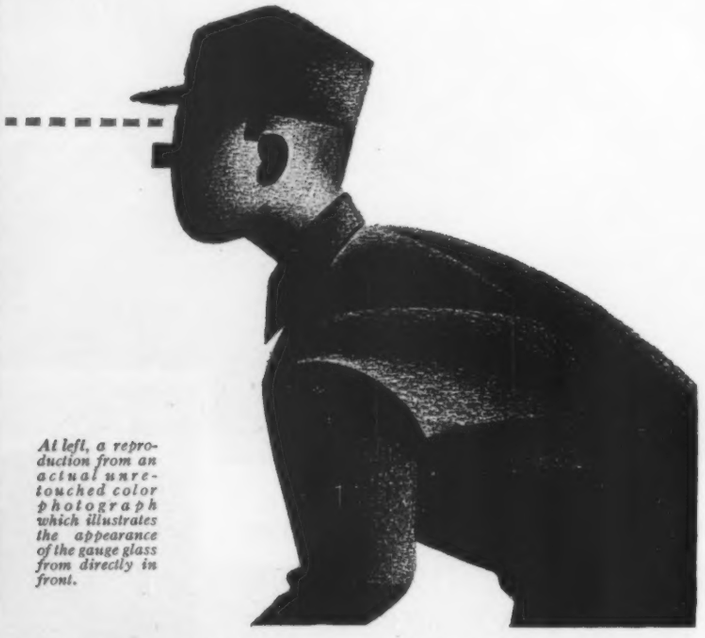

At left, a reproduction from an actual unretouched color photograph which illustrates the appearance of the gauge glass from directly in front.

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CORNING Glass Works Corning, New York

Pyrex Gauge Glasses

Asphalt Institute Elects Officials

Herbert Spencer has been reelected president and managing director of the Asphalt Institute. Other officials chosen at the meeting of directors March 11 are:

David Waxman, Shell Oil Company, chairman of the executive committee; J. A. Blood, Standard Oil Company of California; C. H. Dresser, Anderson-Prichard Oil Corporation, and H. B. Pullar, Berry Asphalt Company, vice presidents; George R. Christie, Standard Oil Company of New York, secretary and treasurer; John N. Smith of the same company, assistant treasurer.

The Byerlyte Corporation, Cleveland, has become a member of the institute.

Ray C. Sackett Joins SAE Staff in Detroit

Ray C. Sackett jointed the headquarters staff of the Society of Automotive Engineers on March 9 to assist in accelerating SAE war program which has developed at an increasing pace since United States' entry into the conflict. Sackett will have his headquarters in the New Center Building, Detroit, and will devote particular attention to working with the SAE War Engineering Board, although he will participate as well in other phases of the broad program now being carried forward under the SAE War Activity Council, supervising agency of all the society's war work.

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NGAA Begins Tests for Standardizing Condensate Well Sampling

FIRST of a series of field tests, through which the Natural Gasoline Association of America will determine recommended equipment and procedure for determining the content of condensate wells, was run in the Stratton field, Nueces County, during the week of April 13. The program calls for similar applications of equipment against full-scale flow in other wells of higher pressures and higher liquid content.

Both commercial equipment and company-owned units took part in the Stratton tests and all owners of these units have been invited to continue as the tests progress through the scale of condensate well types. The work is under the direction of the high-pressure division of the association, which will make its recommendations following completion of the field experiences.

Conditions similar to those prevailing at Wardner 9, Stratton field, owned by The Chicago Corporation, will continue for remaining tests. Field laboratories, gravity balances and other test units will complete their work while a well is under full-scale production, which is being recorded constantly, since the flow is into a calibrated separator. Calculations based on results of test equipment will be checked against actual output. The person in charge of the test maintains the full scale flow and sets it down beside calculations from testing.

Content tests are made on condensate wells for a number of reasons, among them being the examination of the well after completion to determine its production characteristics; examination of a number of wells in a given area to determine the feasibility of cycling operations; and examination of wells to determine their relative contribution to the whole in a cycling operation. This last is essential for the allocation of royalty and other distribution of production income.

Testing of condensate wells is done by one of two general methods: (1) Full-scale tests involving measurement and sampling of the entire well production. This is expensive in outlay and personnel required to obtain an accurate measure of well capacity, but serves as guide or master control against which accuracy of all other methods is checked. (2) Small-scale testing in which a relatively small representative portion of the well affluent is withdrawn from the flow stream and examined.

Something over half a dozen sampling devices are in use in various areas and in quantities ranging from single units in the hands of their developers to multiple installations with wide distribution. Most of these units are variations on the principle of a small tube inserted into the flow stream of the well. There is an equal or even greater number of devices and test methods being used for evaluating the sample, nearly all of which involve separation at some pressure suitable to the individual operator, with or without examination of the separated gas at the option of the operator.

Gas volumes handled in these tests vary from around 20 cubic feet up to several hundred feet, depending upon the method being employed and the operator's views on the subject.

The flow stream of practically all condensate wells contains retrograded liquid. The amount varies widely, as it is a function of the reservoir fluid and reservoir temperatures and pressures and surface temperatures and pressures. As surface temperatures can vary widely with changes in flow rates, the relative amount of retrograded liquid is entrained as a finely divided mist, and a part of this liquid collects and flows along the walls of the tubing as a liquid film, flow being uniform or by heads, depending upon the interrelation of wellhead factors. No sampling tube in the center of the stream is able to sample this film liquid. Several of the devices now in use atomize the entrained liquid into an entrained mist and then through a sampling tube located at the optimum point obtain a representative sample.

In the Stratton field test a 1000-pound separator, from which the automatic dump mechanism had been removed and on which a specially calibrated sight gauge had been installed, was set up adjacent to the well, and tied in to one side of the Christmas tree through a line containing two variable chokes, each choke being equipped with up- and downstream gauges to show pressure drop. The second choke was used to regulate pressure of well flow through the separator unit at a standard figure of 900 pounds, separator outlet pressure being held uniform likewise, this at 400 pounds per square inch.

To permit uniform operation of the separator, the well flow was led through a heat exchanger and a uniform temperature of 83° F. maintained at the inlet to the separator. The exchanger was cooled by expanding a portion of the efflux gas from the test through a needle valve and permitting it to exhaust through the exchanger and thence to open air, the remainder of the gas being vented to air.

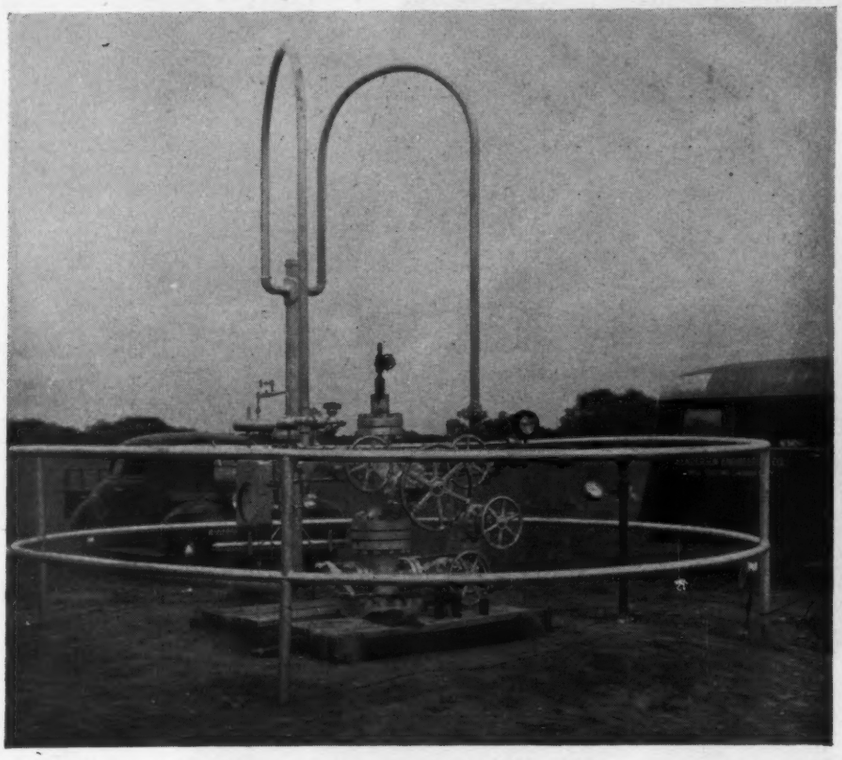
Accurate calibration of the liquid content of the separator was attained through repeated volumetric measurements of liquid between marks on the calibrated sight gauge attached to the separator. Checks on the amount of liquid produced by the well were taken by blowing the unit down below the lower gauge mark, and then allowing it to fill normally. Time was checked on a stop watch as the liquid level passed the lower gauge mark, and again as the upper mark was passed, a simple calculation then giving the amount of liquid per time interval.

Liquid from the separator was bled through a needle valve and quarter-inch line to a stock tank, and there gauged as check on the run determinations. This stock tank was checked for temperature, and a uniform back pressure held on it by means of a regulator which vented gas as liquid was run in, but which prevented free venting of gas to air, and thus held down evaporation losses.

Water separated out during the test was drained at intervals between time-checked runs and accurately gauged to afford means for computing water production against the total liquid output of the well.

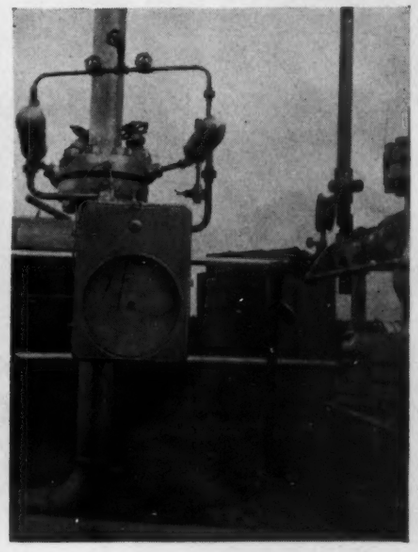
Recording meters were setup to

NGAA Standardized Condensate Well Sampling

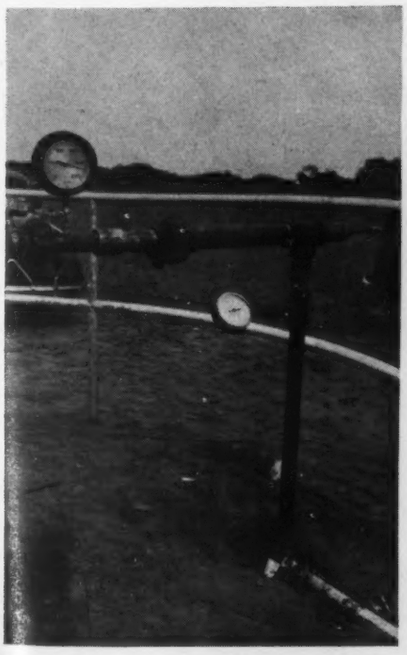


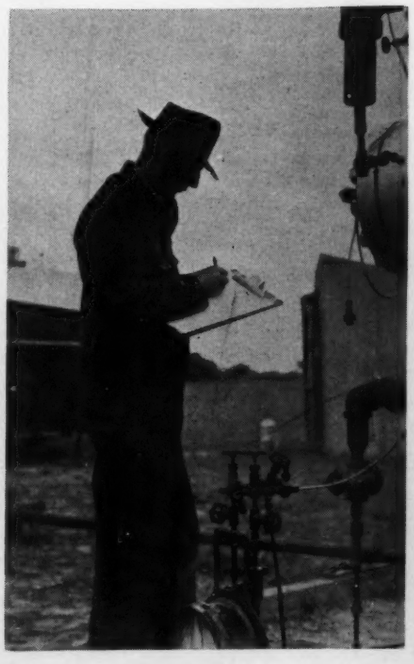
Chicago Corporation's Wardner 9, in the Stratton field, Nueces County, chosen as test well for the first run. Gas carried normally 0.8 gallons of condensate to 1,000 cubic feet under a pressure of 2,170 pounds and at a well-head temperature of 133° F.

An orifice meter with dual pens, normally checked flow of gas from well into line tied in with gathering system to field's cycling plant. Since flow line gate was closed during tests, record showed well pressures.



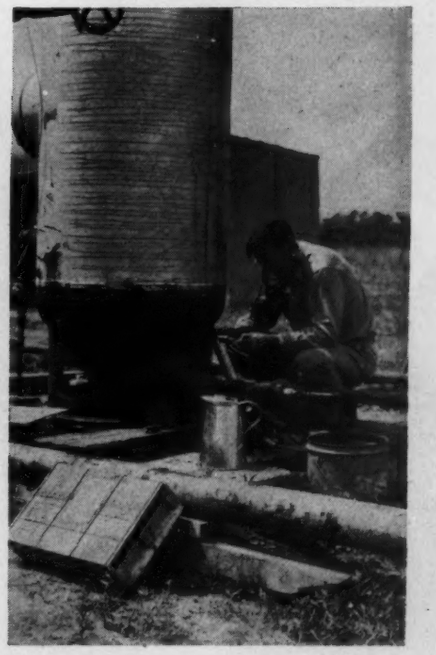
Well flow, dropped by stages through chokes, was taken from branch of Christmas tree through temporary lines with gauges flanking each choke to show amount of pressure drop. Second choke was regulated manually to maintain desired working pressure on separator.





A 1,000-pound separator was mounted near the well, and carefully calibrated to determine its liquid content between marks on the visible gauge. A choke at the separator outlet permitted accurate maintenance of the desired discharge pressure at 400 pounds. H. L. Oder, Cities Service Oil Company, Bartlesville, Oklahoma, was in charge of the set-up.

Temperatures within the separator were maintained at a predetermined figure of 83 degrees Fahr. Water settling within the separator was withdrawn, during interim periods, into calibrated container and volume thus taken was integrated with total well output. L. B. Wood, Phillips, catches a high-pressure sample.



[*Continued*]

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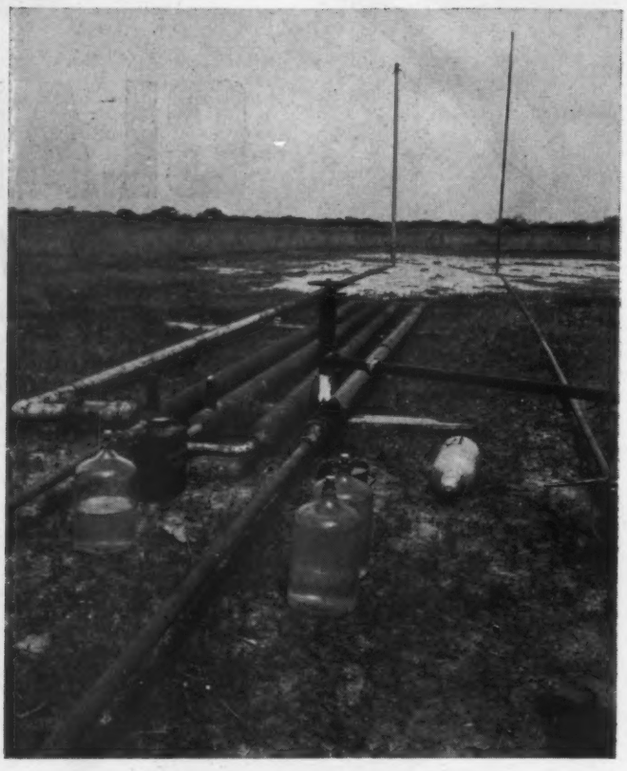
Natural Gasoline Association of America Seeking

A recording meter checks and charts the outflow gas with nearby gauge to aid in maintaining close watch on the pressure of the stream leaving the separator and thus insure unvarying conditions throughout the entire run. This regulation was by means of adjustable choke at separator, needing adjustment only when variation in amount of gas run through heat exchanger altered line conditions at vent.

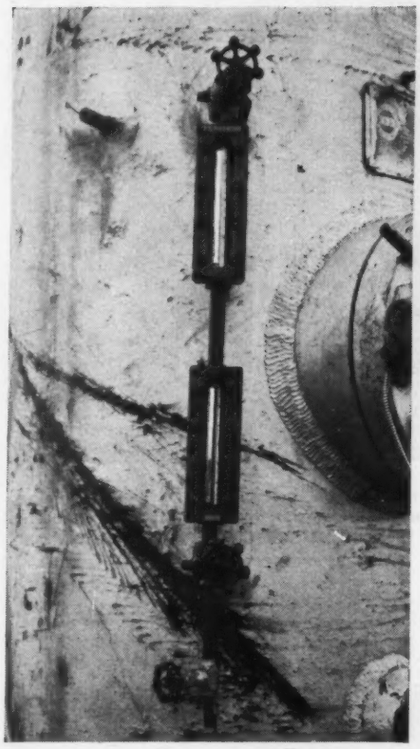


A heat exchanger tied into the gas line between well and separator, permitted the stream entering the separator to be closely checked at the predetermined reading, expanded gas from the discharge being regulated through choke to obtain cooling effect on incoming stream. Spent cooling gas was vented to air through high disposal stack, as was that released after passing through separator system.

Backpressure of 8 pounds per square inch was maintained on the stock tank to insure against loss of liquid at this stage and permit bulk check against separate runs for overall well total. An orifice meter recorded flow of gas from the stock tank and gave a pressure chart.

The stock tank carried an emergency relief valve, and was protected on the vent line with a standard gate, beyond which was set the automatic regulator to hold desired back pressure on the contents yet permit the gas to flow while condensate was being run into the tank.

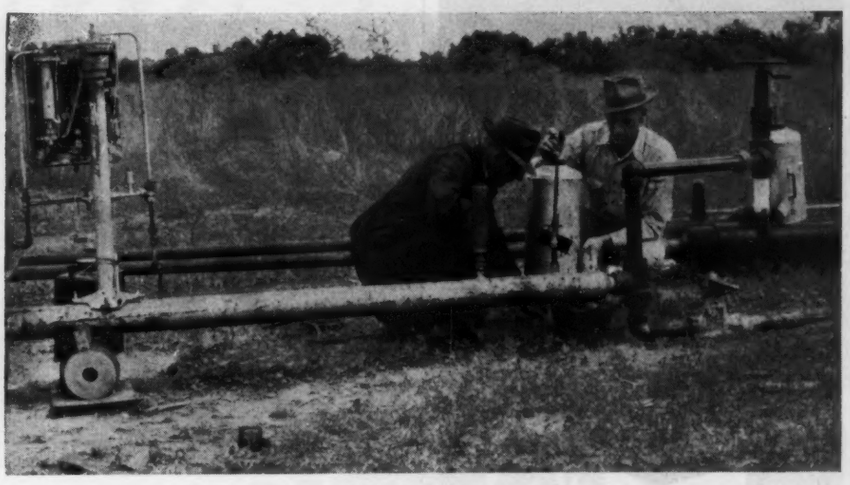
Standardized Calibration for Condensate Well Sampling



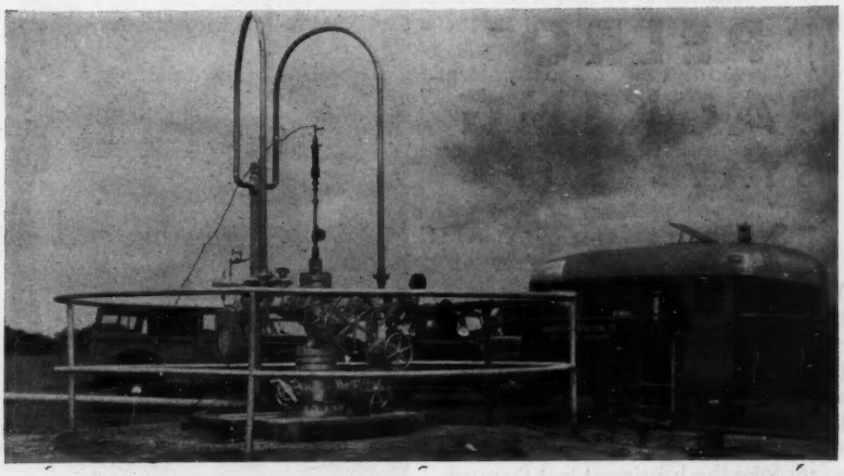
Tandem sight glass gauges with calibrated scales and eye-level mirrors to avoid parallax were used with a stop watch to determine the rate of condensate flow by the well, quantities between bottom mark and top gauge being taken on the run with the watch as fluid rose from below gauge level and passed above it.

Each testing unit, as it was tied in for a check run against actual and known well output, was the center of an interested and keenly observant group of experts, many of whom recorded the findings photographically as well as by field-drawn charts and graphs.

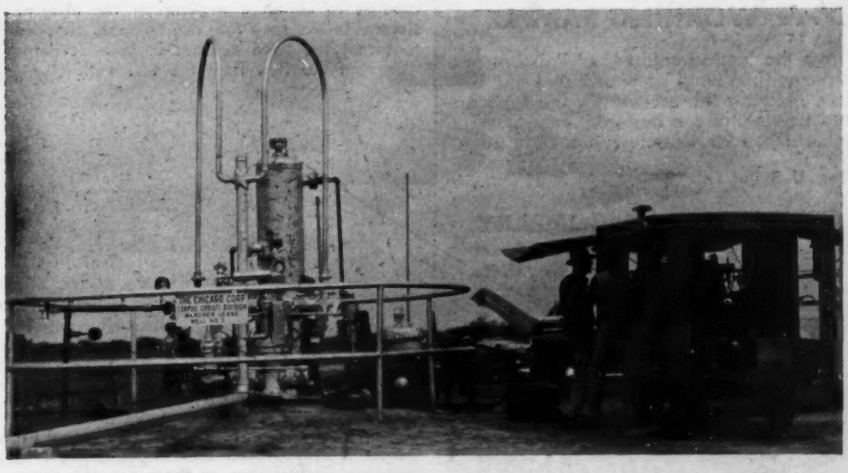
Another of the portable laboratories, with ventilating sides and completely independent of its traction unit while running a test. A gasoline engine powers the equipment, and drives a small generator to permit 24-hour operation.



Samples of the well gas were collected by the test crew and sent to various laboratories and schools for accurate determination of gas characteristics for check against findings on the job. Bombs were also filled with the distillate for thorough laboratory analysis.



One of the portable field laboratories, drawing a sample from a dart lubricated well down the tubing and equipped to process a small sample of the well flow in a manner similar to its handling in a larger, commercial unit.



[Continued]

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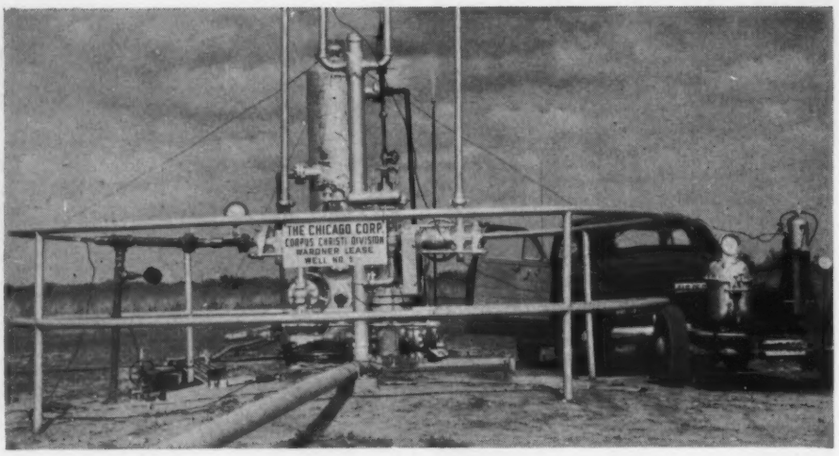

Still another trailer-mounted test unit, this one reducing the well pressure to a predetermined maximum of 250 pounds before separating fluid and measuring gas through accurately calibrated volume meters, while a similar unit passed a specified volume through activated charcoal.

S. M. McAnelly, Lone Star Gasoline Company, carefully checks a gravity balance before proceeding to obtain a reading on the effluent stream. In one such run, two balances checked to within the third decimal in their readings on the flow from the test well.

An electrically actuated specific gravity instrument, drawing power from a standard 6-volt automobile battery, and drawing a sample from the same outlet delivering to all gravity test units. This instrument checked closely, and instantly indicated even such slight changes in separator performance as those brought about by blowing condensate to the stock tank.

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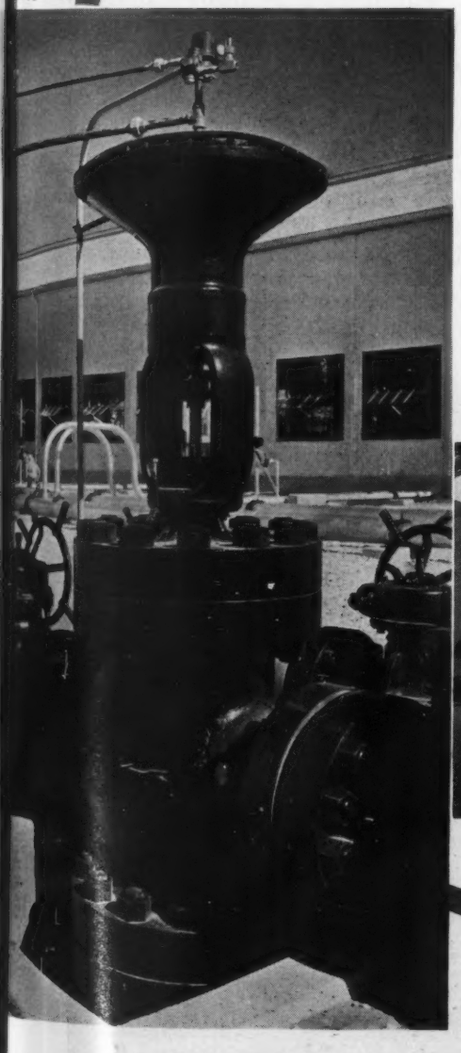
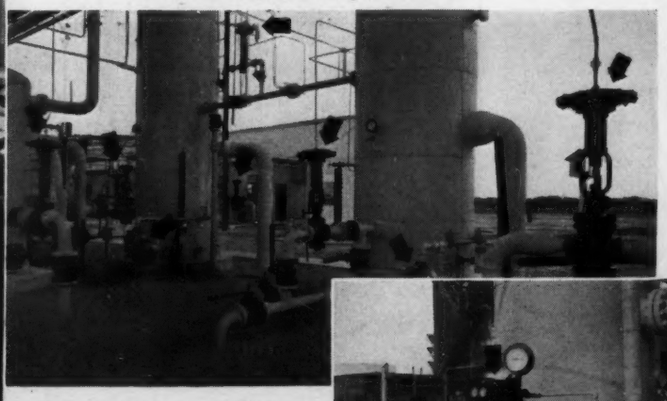
8" Fisher Type 57T specially designed diaphragm control valve. Operates as emergency shut-off valve for an entire gulf coast recycling plant.



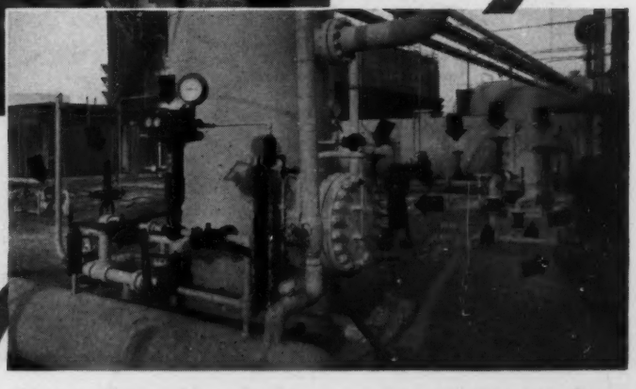
Fisher Governor Company offers you the ideal source of complete Automatic Control Equipment . . . all from one source of supply and with one responsibility for satisfactory operation. Fisher Automatic Controls include: Diaphragm Valves . . . Liquid Level Controllers . . . Drainers . . . Lever Valves . . . Float Valves . . . Reducing Valves . . . Relief Valves . . . Boiler Gas Fuel Governors . . . Pump Governors . . . Safety Shut-Off Valves . . . Strainers . . . Traps.

Every Fisher control is individually built to meet your exact operating conditions thereby insuring best possible results. Fisher engineers will gladly recommend the control equipment best suited to your requirements.

Fisher Automatic Controllers are playing an increasingly important part in the production of high octane Aviation Gasoline and other essential war time petroleum products. Hundreds of existing plants, large and small, are Fisher equipped to give them the better automatic control that means increased production.



Fisher pilot operated diaphragm control valves and continuous drainers "in command" at a large gasoline plant.



Another group of Fisher controls including level-trols, Wizard pilot operated regulators, diaphragm valves, and continuous drainers insures best results at this modern refinery.

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1872 — 70TH ANNIVERSARY — 1942

check the flow from the well, and again the efflux from the separator, these units being of the usual orifice-type meters used in gas production. A similar recording meter kept check on the pressure variations within the stock tank, and provided record of all changes in the receiver.

Provision was made at the well head for lubrication into both tubing and casing annulus of the usual sampling devices, while taps along the flow lines permitted attachment of sampling units at various points between the well and the final reduction in pressure at the valve maintaining the desired back pressure on the separator set-up. In order to make all runs of like sampling devices uniform, those working with similar samples were connected in tandem or in series to the same outlet, so as to provide uniform flow conditions. Where two or more units were operated at the same time, a branch was introduced in the sampling line outside the usual hook-up, so as to leave the flow conditions on the calibration set-up unchanged.

Distillate samples were taken into bombs at the lower connection of the gauge tie-in, so as to provide uniform withdrawal for all samples taken. Gas samples for laboratory examination were taken from the same outlet as samples for specific gravity tests, being drawn into bottles under water or into typical bombs as required by the analysis method to be followed.

The actual runs on the well were under the direct supervision of H. L. Oder, loaned by the Cities Service Company from its Bartlesville, Oklahoma, organization for this purpose. The full-scale tests were checked and recorded by him, and were maintained throughout the day from the inception of the tests until the last sampling unit had been calibrated. The data collected from the separator were all recorded, to these being added the figures obtained by each operator of a sampling device, all figures being handled by the test supervisor, without the operator of the sampling device having opportunity to determine actual well performance. This maintained the sampling devices on a normal field basis, the values shown by the sampling device being comparable to those obtained under commercial testing conditions, with NGAA having on hand full-scale-test data against which the showings of the sampling device might be checked.

The tests were thrown open to all manufacturers of sampling equipment, and they were offered full facilities for as extensive a test or run as was felt desirable to make the desired showing on the well. The second of the series of tests is scheduled to be run as soon as a well of the desired characteristics can be made available and the full-scale-testing equipment, including separator and heat exchanger, can be transferred to the new site and set up.

NGAA Anniversary to Be Wartime Program

For its twenty-first anniversary the Natural Gasoline Association of America will hold its first convention under the influence of war. Lack of normal transportation plus the fact that many technologists of the industry are engaged in work related to military activity is responsible for confining the meeting to two days, May 14 and 15. Sessions will be held in the Mayo Hotel, Tulsa.

The afternoon of the second day will be devoted wholly to consideration of natural gasoline in the war program with specific reference to the special products that the industry is being called upon to provide. Transportation and priorities will be discussed. Speakers from the office of the Petroleum Coordinator lead this part of the program which will amount to an open forum on all phases of the relationship between the government and the industry.

The 1942 meeting will inaugurate the entry of the organization into field and laboratory work through which it is seeking to determine the characteristics of high-pressure wells of the condensate type, along with the liquid content of the hydrocarbons of this nature. Last month the association sponsored the first series of tests on a well in the Stratton field, Neuces County, Texas. (See page 106.)

Dr. Donald L. Katz of the University of Michigan, who has been retained for correlating existing data, plus what is learned from further field tests, will appear on the program of the 1942 meeting.

Both the banquet and the buffet supper, the evening of May 14, will be sponsored by the Natural Gasoline Supply Men's Association.

Three committee reports will be made the first day of the convention. The report of the Gas Testing Committee by H. L. Oder, Cities Service Oil Company, will present a revised method and recommendation for reclaiming both charcoal and glycerine.

THE LOOK BOX

CONVENTIONS

JUNE 8–11	American Society of Mechanical Engineers, Semi-Annual Meeting, Cleveland.
22–26	American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City.
OCT. 12–14	American Society of Mechanical Engineers, Fall Meeting, Rochester, N. Y.
16–18	American Institute of Chemical Engineers, Netherland Plaza Hotel, Cincinnati.
25–29	National Lubricating Grease Institute, New Orleans.
NOV. 9–13	American Petroleum Institute, Stevens Hotel, Chicago.

The report of the Technical Committee, of which H. H. Beeson, Sabine Valley Gasoline Company, is chairman, will include presentation of new standard tables of physical constants for the principal hydrocarbons, a new alternate standard for determining the specific gravity of liquefied petroleum gases by the hydrometer method, a new volume-temperature factor for pure liquefied petroleum gases, their mixtures and for natural gasoline.

H. A. Montgomery, Hanlon-Buchanan, Inc., will show further progress of two years of research when identical gas samples have been exchanged and analyzed in the laboratories of 15 different companies. Recommendations will be given for changes in both procedure and apparatus in obtaining accuracy and duplicability. The title of his paper will be "Elimination of Errors in Fractional Distillation of Gases."

The first report of the Technical Committee of the High Pressure Gas Division will be made by C. H. Gee, the La Gloria Corporation, under the title "The Testing of High Pressure Gases."

Celebration of the twenty-first anniversary of the association will have its climax in the banquet the evening of May 15. William B. Stout, president of Stout Engineering Laboratories, Detroit, will be the speaker.

Concerning his appearance the association has given this analysis of his talk:

"He will tell what the presently accelerated engineering progress will mean to the post-war era in terms of more efficient, though radically changed designs for both cars and airplanes. A non-technical discussion of a highly technical subject and as covered by Stout it has all the interest of drama, the authority of a text book and is spiced with the speaker's own inimitable humor and homely philosophy."

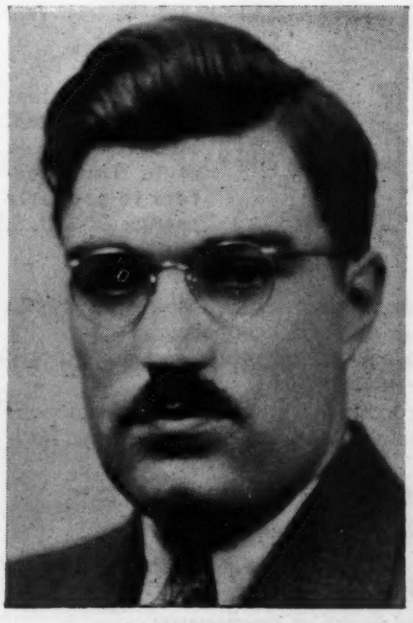
The annual address of Ray E. Miller, association president, will be part of the banquet program, which also will include presentation of the Hanlon Award.

The banquet as well as the buffet supper the evening of May 14 will be sponsored by the Natural Gasoline Supply Men's Association.

The technical program of the second day will consist of two papers. J. W. Wilson, Cities Service Oil Company, will discuss "The Extraction of Butane." This will be a detailed discussion of the various methods of obtaining high yields from butane at natural gasoline plants, including technical details, efficiencies and general economics."

Dr. Donald L. Katz, University of Michigan, will offer "A Suggested Standard Method for the Measurement of High-Pressure Gases." This will be a correlation of all authoritative data on

RAY E. MILLER
President



DONALD L. KATZ
University of Michigan

WILLIAM F. LOWE
Secretary

the subject, combined with extensive field surveys and presenting specific recommendations for standardizing calculation of deviations from Boyle's law, high-pressure orifice-meter measurement and supercompressibility factors.

Speakers and subjects for the afternoon program May 15 are:

"The Tank Car Situation, With Specific Reference to the Natural Gasoline Industry," C. R. Musgrave, Phillips Petroleum Company, chairman subcommittee on Tank Cars and Trucks, OPC Transportation Committee.

An address by D. E. Buchanan, president of Hanlon-Buchanan, Inc., and a member of the OPC staff, Natural Gas-Natural Gasoline Section.

An address by Justine Wolfe, attorney, Natural Gas-Natural Gasoline Section, OPC.

Officials of the association are Ray E. Miller, Hanlon-Buchanan, Inc., Tulsa, president; H. H. Beeson, Sabine Valley Gasoline Company, Shreveport; H. A. Eells, Cities Service Oil Company, Bartlesville; J. R. Jarvis, Lone Star Gasoline Company, Dallas; and J. W. Vaiden, Skelly Oil Company, Tulsa, vice presidents; William F. Lowe, Tulsa, secretary-treasurer.

Bureau of Mines Opens Franklin Laboratory

The new field office of the United States Bureau of Mines at Franklin, Pennsylvania, was opened April 15, with C. J. Wilhelm in charge. S. S. Taylor and E. M. Tignor are members of the staff.

The office will devote much of its efforts to methods of increasing output of oil in the Appalachian region.

NPA Hears of Progress of Refining at War

Further progress of the refining industry in its efforts to supply the critical products of the military effort was brought to attention of the National Petroleum Association in Cleveland, April 16 and 17. Wright W. Gary, director of refining, Office of the Petroleum Coordinator for National Defense, gave most of the information on accomplishments in refining.

Dr. John W. Frey, marketing director, outlined the problems of meeting gasoline demands, especially in areas affected by transportation.

The effect of the rubber shortage on gasoline consumption was outlined by C. L. Burrill, Standard Oil Company of New Jersey.

Hanson W. Baldwin, military expert of the *New York Times,* discussed the military situation.

The association added six additional trustees to its governing body: Aubrey D. David, Bradford-Penn Refining Company; Rudolph Sonneborn, Franklin Creek Refining Corporation; K. P. Proctor, National Refining Company; C. L. Maguire, Roosevelt Oil Company; Walter E. Pew, Sun Oil Company; W. W. Fleming, Ohio Oil Company.

The accomplishment of doubling the output of 100-octane aviation gasoline within three months from existing plants was a significant feature of the talk by Wright W. Gary. There are now 50 refining plants having a part in the aviation-gasoline program. Several months back technologists of most of these concerns met and worked over plans for changing operations and working in cooperation with each other with the result that the aviation gasoline supply was doubled.

Plants now under construction or being designed provide for aviation gasoline capacity by the end of 1943 in greater quantity than military authorities consider essential. Gary, however, urged refiners to continue with their plans on the manufacture of 100-octane gasoline, since he is convinced that it is one product that will not suffer in consumption at the conclusion of the war.

He said that OPC had classed refining plants under four divisions:

Those making 100-octane-aviation gasoline; those making 91-octane gasoline; those making products under Lend-Lease contracts; other plants.

The plan of the department is to keep plants of the first class operating at whatever rate is essential to supplying the base stocks for 100-octane-aviation gasoline. If called upon to reduce total throughput, deficiencies in motor fuel and other non-critical products would be met from plants in the other classifications. Where any plant must shut down, his plan is to have supplies for its market cared for by plants which are essential to the war program.

The situation wherein refiners are running abnormal amounts of light products into fuel and thus increasing its cost, has the attention of his office in the effort to gain higher price ceilings for fuel oil.

In regard to new plants Gary reiterated his statement made before the meeting of the Western Petroleum Refiners Association, March 25, that designs be made to include provision for the critical products, since these units will be looked on favorably. He also urged engineers to simplify designs and to strive for limited use of alloys, even to the extent of a shorter-than-normal expectancy of use.

Equipment Association Will Entertain NGAA

Entertainment, a buffet supper May 14 and a banquet May 15, for the annual meeting of the Natural Gasoline Association of America will be provided by the Natural Gasoline Supply Men's Association. This organization of manufacturers and distributors was formed in 1928 for the purpose of sponsoring entertainment as well as working in cooperation with the organization of gasoline manufacturers.

Among its other activities are publication of the *Technical Manual,* the fourth edition being distributed following the meeting in Dallas in 1941. This edition has been exhausted.

Officials of the association are: L. S. Allen, National Tank Company, Tulsa, president; George Probst, Clark Brothers Company, Tulsa, and D. A. Leach, Chicago Bridge & Iron Company, Tulsa, vice presidents; C. D. Peterson, Fisher Governor Company, Tulsa, treasurer. William F. Lowe is secretary, combining that work along with similar duties for the Natural Gasoline Association of America.

In addition to the officials the following are directors: J. H. Satterwhite, Westcott & Greis, Tulsa; A. M. Buxton, Cooper-Bessemer Corporation, Tulsa; W. W. Woobank, Woobank Pump & Machinery Corporation, Tulsa;

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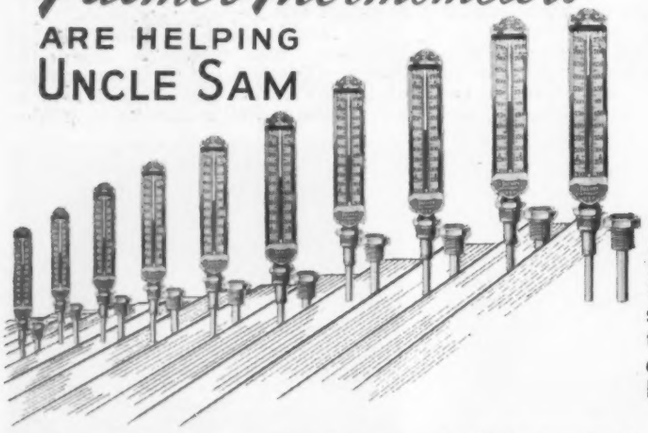

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PALMER THERMOMETERS are known for their sturdiness, guaranteed permanent accuracy, their sensitivity and the easy-reading "Red-Reading-Mercury" feature.

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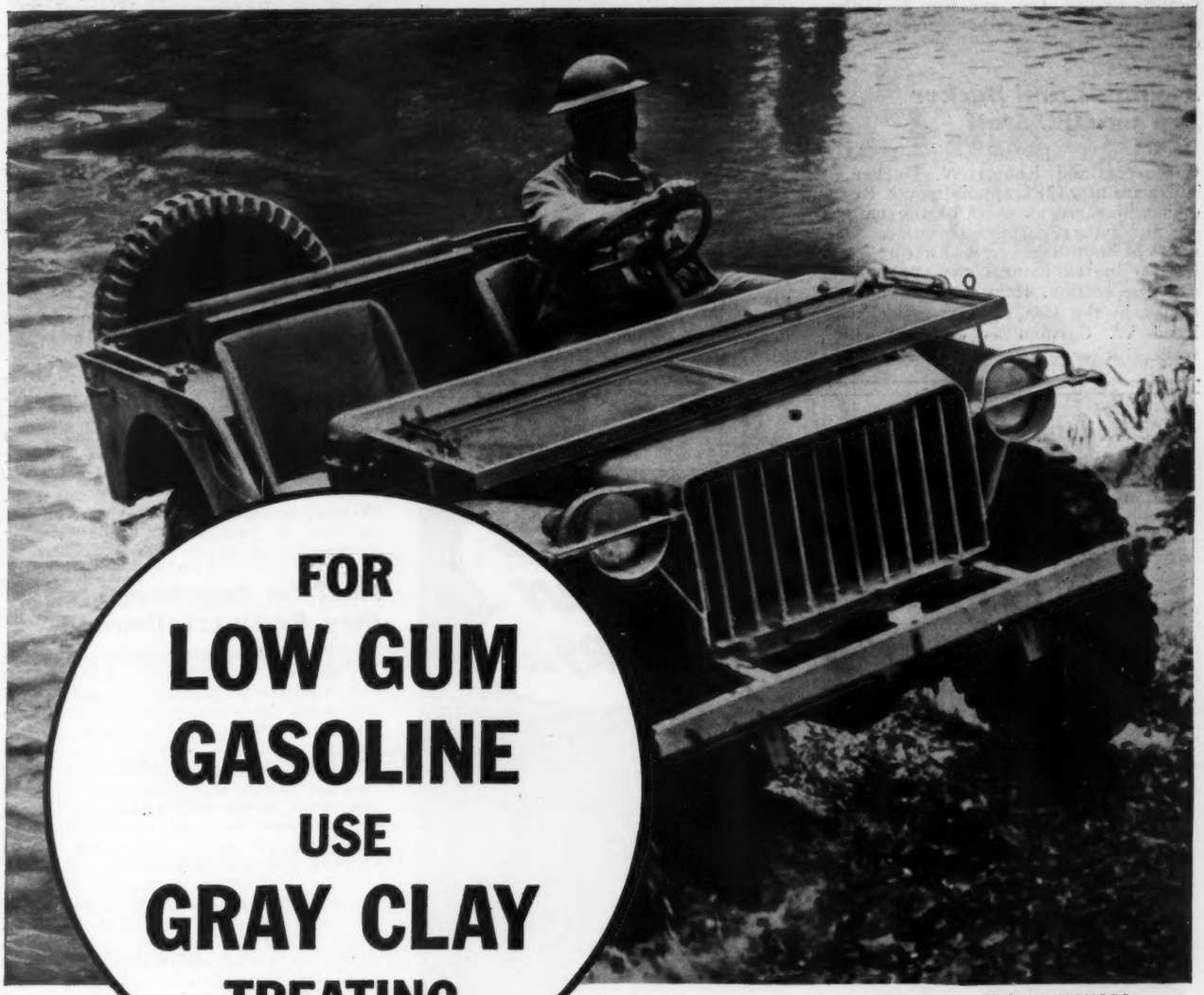

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TREATING

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Gray refined gasoline is Gum Stable because gum-forming elements are removed

Today gasoline may be months in transportation and storage before it is used. If gum-forming elements are present in the gasoline, they will have every opportunity to break down and form gum.

Gray Clay Treating prevents excessive gum because gum-forming elements themselves are removed.

Installed Gray Clay Treating capacity is now approximately 150,000 barrels per day.

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V. C. Canter, Frick-Reid Supply Corporation, Tulsa; William Gebo, Ingersoll-Rand Company; R. T. Roberts, Goulds Pumps, Inc., and Ray E. Miller, president of the Natural Gasoline Association of America.

Reynolds and Ducker Are on OPC Staff

Kenyon L. Reynolds of Pasadena, California, and Robert W. Ducker of Tulsa are new OPC appointments. Reynolds will serve as chief of the natural gas and natural gasoline section for District 5, and Ducker as natural gas analyst in the natural gas and natural gasoline section. Reynolds will be stationed in the Los Angeles office, with Reed W. Garman as assistant chief, while Ducker will serve in Washington.

Committee to Study Civilian Rubber Supply

In an effort to bring about as much as 300,000 tons of synthetic rubber for civilian use, the Petroleum Industry War Council has named a committee which will make a thorough study of the feasibility of adding sufficient capacity. Since the council passed a resolution which set forth the need for a civilian source of rubber, the program in behalf of the military effort has been increased to 800,000 tons per year.

To speed action, the committee is authorized to make an immediate study of the problem, especially that of butyl rubber, and it is directed by the chairman to develop and prosecute without any further action by the council, a program designed to obtain synthetic rubber for essential civilian uses.

The committee named by Chairman Boyd, with the approval of the Deputy Petroleum Coordinator, is composed of W. S. S. Rodgers, president of The Texas Company, chairman, and the general chairman of each of the country's five regional districts as established by Petroleum Coordinator Harold L. Ickes. The district general chairmen are, John A. Brown, president of Socony-Vacuum Oil Company, New York; Frank Phillips, chairman of the board, Phillips Petroleum Company, Bartlesville; C. F. Roeser, president, Roeser and Pendleton, Fort Worth; W. H. Ferguson, vice president, Continental Oil Company, Denver, and W. F. Humphrey, president of Tide Water Associated Oil Company, San Francisco.

In addition, the following individuals have been named to committee membership: Eric V. Weber, president of Eureka Oil Company, Cincinnati; Jacob France, president of Mid-Continent Petroleum Corporation, Tulsa; R. van der Woude, president of Shell Union Oil Corporation, New York; H. F. Sinclair, chairman of Consolidated Oil Corporation, New York, and Dr. Robert E. Wilson, president of Pan-American Petroleum & Transport Company, New York.

Nazi Oil Requirements May Be Overestimated

Indications that efforts to determine the amount of petroleum products being consumed in Europe have been erroneous have been analyzed by the American Petroleum Institute as follows:

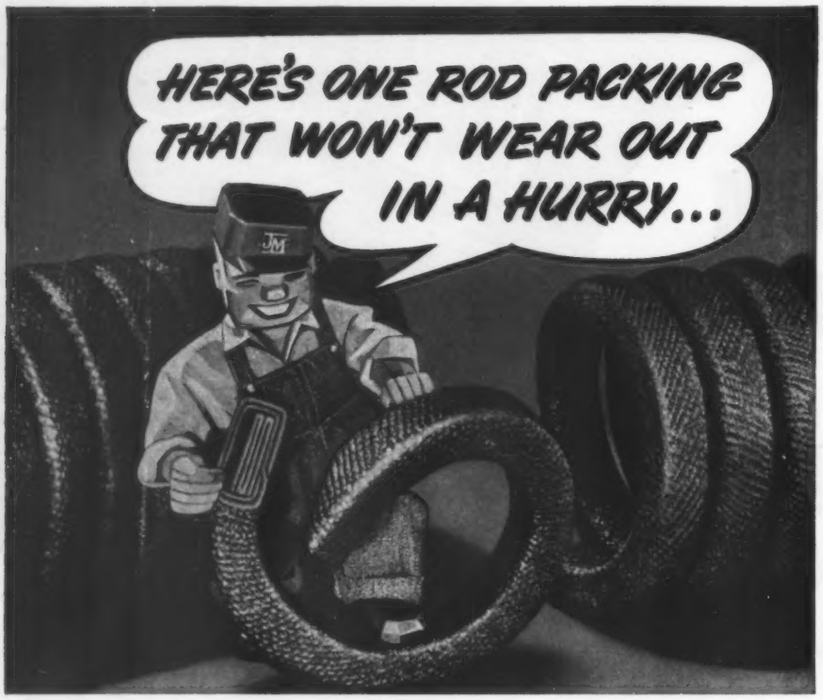
"Hitler's Europe must be using much less petroleum than has been hitherto suspected, recent calculations by oil experts reveal, but wide speculation still continues about the extent of his oil resources and how long they can last.

"The maximum production of crude oil and all substitutes for petroleum in all Axis Europe in 1941 was not more than 130,000,000 barrels, or about as much as the United States alone produces in a month, according to compilations by Dr. Gustav Egloff reported at the recent meeting of the American Chemical Society. Other sources indicate that production of petroleum and synthetic oils from coal did not exceed 100,000,000 barrels last year.

"The rate of consumption, therefore, cannot be anywhere near the immense quantities suggested by many experts. If consumption were at the rate of 21,500,000 barrels a month, with 17,000,000 barrels required for the Russian front, as has been suggested, the total 1941 demand would have been 255,000,000 barrels, or 125,000,000 barrels more than the maximum production. It is incredible that Hitler's reserve stocks could withstand such a drain.

"The London 'Petroleum Press Service' in its April issue reports that even the widely-held estimates of 7,500,000 to 15,000,000 barrels a month consumption on the Russian front must be far too high. If these estimates had any foundation in fact, this paper says, 'the struggle would by now have ended in a Nazi defeat.'

"Although predictions have been made regularly since the war began that Germany was near the end of its oil reserves and would falter soon, 'there would appear to be no evidence that the German military machine is as yet handicapped by any immediate or



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ALKYLATION—Processes for preparing synthetic aviation blending stocks of high quality and in high yield.

GAS-DEHYDROGENATION—Catalytic conversion of paraffin hydrocarbons to corresponding olefins, such as butane to butylene.

CATALYTIC ISOMERIZATION—Reconstruction of hydrocarbons to improve chemical and anti-knock characteristics.

CATALYTIC DESULFURIZATION—Treatment of aviation base stocks and motor fuels to obtain greatly increased tetraethyl lead susceptibility.

COPPER SWEETENING—Processes for treating light oils under conditions eliminating harmful effects commonly occurring in other sweetening processes.

POLYMERIZATION—Catalytic process used in manufacture of aviation and motor fuels.

GAS REVERSION—Thermal processing of gaseous hydrocarbons with light or heavy oils to produce high octane stocks with improved yields.

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U. S. A.

threatened shortage of oil for fighting purposes. The Germans would have been incapable of withstanding the furious Russian counter-offensive—still less of preparing for a renewed drive on a gigantic scale—if the strain on their oil resources had not remained within bearable limits.'

"Most oil experts have agreed that Germany's chief deficiencies are in high-grade lubricating oils, which are difficult of manufacture from synthetic oils. The Rumanian, Polish, and Czechoslovakian crude oils available also are known to be relatively poor sources of lubricants. A prominent war correspondent recently reported that these facts suggested that Germany's spring objective would therefore have to be Russia's Caucasus oil fields, for the crude oil from Baku makes high-quality lubricants, while the petroleum from Iraq and Iran is not nearly as suitable.

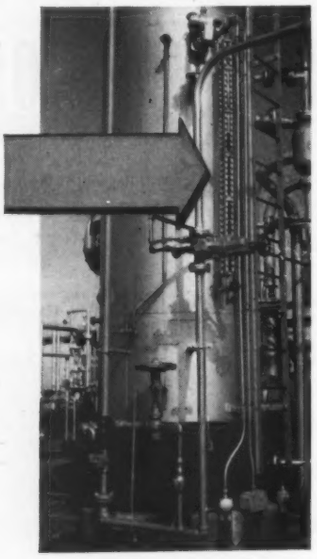
"On the other hand, the 'Petroleum Press Service' story indicates the possibility that Germany's chemists have been able to make great improvements in the synthetic-oil processes and are producing good quality lubricants from coal oils.

"The actual facts, of course, despite all inferences and informed guesses, must remain unknown. It is obvious that the Nazis have nowhere nearly as much petroleum as could be used, and it is probable that their reserves are very low. Yet they evidently are preparing a massive offensive which would be impossible without the most careful attention to their oil position."

JERGUSON

Reflex Gages

SOLID BLACK where there's liquid



Transparent Gage

A complete line of "thru-vision" gages for use where condition as well as level of liquid must be determined. Pressures up to 2000 pounds at 100° F., or up to 600 pounds at 1000° F.

Reflex gage, side hook-up type.

When the above picture of the Jerguson Reflex Gages on a column was taken, the camera was some distance off. It's obvious that the limit of visibility is many feet still further away. So, if you want real visibility, make it a Reflex Gage.

If you want strength, make it a JERGUSON with its forged and alloy steel parts . . . its strong U-Bolt assembly . . . and its scientifically tempered special glass. Standard units are recommended for pressures up to 3200 pounds at 100° F., or up to 1200 pounds at 1000° F.

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National Power Show Plans Taking Shape

Plans are developing for the National Exposition of Power & Mechanical Engineering, scheduled for Grand Central Palace, New York, November 30 to December 5, 1942. Better known as the National Power Show, this widely recognized biennial event assumes an important role in helping industry's power facilities to meet the great demands of war production.

As an aid to increasing the production of war materials, displays will show ways and means of utilizing existing facilities to obtain more out of them; will educate the thousands of new operating men on the latest methods and equipment for the generation, transmission and utilization of power. Methods of conserving fuel, obtaining greater production through more accurate control of operations, utilizing substitute materials to overcome priorities problems, providing adequate emergency facilities, etc., will also be promoted. Engineers and operating men will learn quickly and conserve vital time by visiting the 1942 Power Show—geared to the Nation's needs.

While the exposition is still many months away, 100 leading manufacturers have already engaged space and are making plans to show and tell what they are doing to provide important help in promoting greater production of war materials. Thirty-four thousand eighty-seven visitors registered at the 1940 Power Show, and it is expected this year's event will attract an even larger audience.

Management is by the International Exposition Company, Grand Central Palace, New York. Charles F. Roth is manager of the exposition, and E. K. Stevens is associate manager.

Lowe Heads SAE Southwest Section

William F. Lowe, secretary of the Natural Gasoline Association of America, Tulsa, has been elected chairman of the Southwestern Section of the Society of Automotive Engineers. He has been secretary-treasurer of the section for the past five years. He succeeds G. C. Richardson, Cities Service Oil Company, Tulsa.

Other officials are: Howard Emmons, Braden Winch Company, Tulsa, vice chairman; Arch L. Foster, Phillips Petroleum Company, Bartlesville, secretary-treasurer; J. H. Baird, Lubri-Zol Corporation, Tulsa, chairman of the committee on papers; J. R. Corbett, Cato Oil & Grease Company, Oklahoma City, chairman of the committee on membership.

Vander Leck Reelected By California Agency

Lawrence Vander Leck, president of Oil Producers Agency of California during the Agency fiscal year 1941-1942, was elected to a second term, ending in April, 1943, by the agency board of directors in their annual meeting recently.

The board also reelected Rush M. Blodget executive vice president.

Vander Leck, vice president of Fullerton Oil Company, is a member of the

LAWRENCE VANDER LECK

production committee for District No. 5, of the Petroleum Industry War Council, of the conservation committee of California Oil Producers, and is a director of the California Oil and Gas Association.

James F. McManmon Now With Hanlon-Buchanan

James F. McManmon, vice president of National Bank of Tulsa, has resigned to accept an executive position with Hanlon-Buchanan, Inc., Tulsa, producers and manufacturers of oil industry equipment. The new executive of the firm has had varied experience in producing, and was an assistant in developing the present Panhandle Eastern System. His first oil field experience was in Burbank following his graduation from the engineering college at Princeton University.

"Governments" Agree on Mexican Expropriation

Mexican properties which American companies claimed in 1938 were worth up to $400,000,000 and which the Mexican government contended were worth no more than $10,000,000 to $20,000,000, actually were rated at slightly less than $32,500,000.

This value was reached by the $8,500,000 for which Sinclair settled its claim in 1940 and $23,995,991 recommended by the joint United States-Mexican commission to settle the claims of the other companies. The commission's recommendations have been accepted by the two governments, establishing a basis for settlement of the long-standing controversy over the Mexican expropriation of foreign-operated oil properties in March, 1938.

The joint commission, composed of Morris L. Cook for the United States and Manuel J. Zebada for Mexico, recommended that Mexico pay one third of the agreed upon sum on July 1, next, and the balance in five annual equal instalments. The commission recommended that Standard Oil Company of New Jersey be paid $18,391,641; Standard Oil Company of California, $3,589,158; Consolidated Oil Company, $630,151; Sabalo

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group, $897,671, and Seaboard group, $487,370.

It is also provided that the Mexican government and each of the American companies shall release each other respectively of all reciprocal claims that may be pending against each other, with the exception of those of the Mexican government against the companies for unpaid taxes and duties, as well as those based on payments legally made by the Mexican government for the account of the companies.

There appeared to be some question as to just how the American claimants will fare under the proposal, it being pointed out that there are claims pending against the companies by Mexican labor groups for alleged back wages and benefits running to considerably more than the $24,000,000 involved in the suggested settlement plan, in which it is specifically stated the Mexican government will not assume any liability for private claims now pending before the Mexican courts.

Announcement of the approval of the two governments to the plan was contained in telegrams exchanged by President Camacho and President Roosevelt. In his telegram, Roosevelt revealed that "from the moment that our two governments agreed upon a procedure for settling the so-called 'petroleum question' I have had every confidence that a settlement would be reached."

It was pointed out in Washington that whether accepted by the companies or not, the official agreement removes the last controversial point between the two countries and paves the way for full wartime cooperation.

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Compressed Air Institute Doubles Cash Prize Awards

Because of the incentive in increased war production the Compressed Air Institute, 45 Washington Place, East Orange, New Jersey, has doubled the total amount of money involved in its prize awards and extended the time for submitting ideas. The campaign is known as the "Blast the Axis Program," which opened as a compressed air idea contest before the Pearl Harbor incident.

According to an announcement made by the educational director, two important new steps have been inaugurated: the value of each cash prize has been doubled, bringing the total to $1000; duration of the program has been extended one month, to terminate July 1, 1942. It is felt that the added incentive coupled with the extended time will result in increasing the number of contestants, immeasurably.

The panel of three judges has been filled and comprises men, prominent in engineering, education and publication fields. Included are Dr. R. L. Sackett, vice president of the American Society of Mechanical Engineers and Dean Emeritus of the School of Engineering, Pennsylvania State College; C. H. Kent, associate professor, mechanical engineering, College of the City of New York; and Charles W. Lytel, associate professor, industrial engineering, New York University.

Nation-wide in scope and open to virtually anyone in industry, the contest is not restricted to employes of companies comprising the Compressed Air Institute. Skill in writing, grammatical construction, will have little weight in awarding prizes. It is not a competition in English composition. The idea and its value to industrial production is the important thing. Entries which have a bearing on some particular aspect of war production, whether or not the idea wins a prize, will be made available to appropriate federal authorities, with full recognition to the contributor.

The Compressed Air Institute is a non-commercial organization, comprising representative manufacturers of air and gas compressors, pneumatic tools, rock drills and compressed-air-operated equipment. Its offices are located in New York City.

Bulletin board posters, describing the idea program, are available without charge from the educational director's office, East Orange, New Jersey.

Bourque Is Consultant on Defense Transportation

A. V. Bourque has been selected as a consultant to Fayette B. Dow, assistant director of defense transportation, whose particular duties concern movement of oil and refined products. Bourque also is executive secretary of the Tank Car Service Committee, Chicago, and will serve as consultant without remuneration.

He has been connected with the petroleum industry for 35 years. He was the first secretary of the Natural Gasoline Association of America and later served as assistant secretary and secretary of the Western Petroleum Refiners Association.

SAE Summer Meeting Schedule Changed

Instead of the summer meeting, originally planned at White Sulphur Springs, West Virginia, May 31 to June 5, the Society of Automotive Engineers will have a series of special local meetings and many of the papers will be published in the July number of the SAE *Journal*. Lack of accommodations at White Sulphur Springs as well as no assurance of transportation were responsible for the change in meeting plans.

The change was given by John A. C. Warner, general manager of the society as follows:

"Continued presence of diplomats of enemy countries at White Sulphur Springs, and the inability of railroads to guarantee sufficient Pullman accommodations for the members to meet at any other suitable place, have ruled out holding the geared-to-war meeting as planned. The papers that were to have been presented, however, will be given at a number of local meetings sponsored by the Society's National Activity Committees, and many will also be published in the July issue of the *Journal*.

"A vast amount of technical information has already been accumulated by engineers of the automotive industry in the conversion of its peacetime facilities to a huge, widespread arsenal. The 'mountain' of technical fare will thus be brought to the engineering 'mohammeds' of the industry, the men responsible for engineering the huge production task ahead—a war-dictated reversal of the ancient proverb."

Johnson Promoted by Continental Oil Company

D. R. Johnson has been appointed superintendent of the Ponca City plant of Continental Oil Company. His elevation from assistant superintendent followed the resignation of Fred Fellows.

Because of the increased volume of work brought about by changes in processing to manufacture critical products for the war program, an additional assistant superintendent has been added to the staff at the Ponca City plant. The two men now holding these positions are H. A. Mertz, who has been superintendent of construction in the engineering department, and L. L. Smith, formerly superintendent of the Continental plant at Denver.

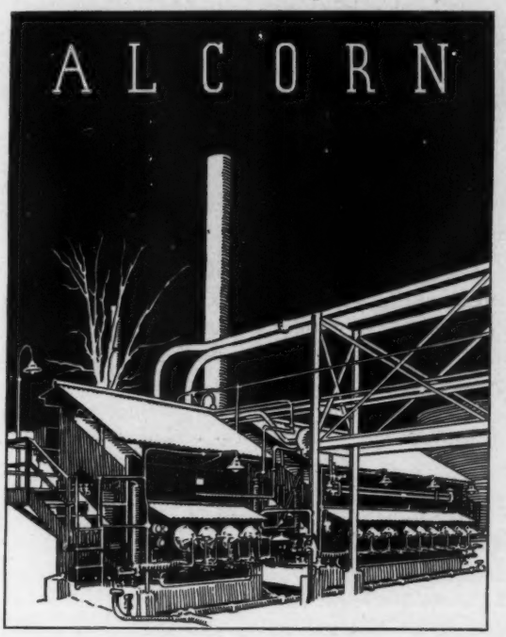
Johnson has been in the Continental organization for 18 years. After two years with Westinghouse Electric and Manufacturing Company, he went to the Glenrock, Wyoming, plant as electrician in 1924. In this plant he was successively shift foreman, fuelman and assistant superintendent in 1928.

He was transferred to the Ponca City plant in 1929 as inspection supervisor and later became chief inspector. In 1935 he became assistant to the manager of the manufacturing department and in October, 1941, he was promoted to assistant superintendent.

Mertz has spent all his service with the company at the Ponca City plant. In 1917 he began work as a mechanic in the garage. After several promotions he became superintendent of the motor transportation department in 1927 and in 1940 was promoted to superintendent of construction.

Smith has been with the company since 1924, when he became a laborer in the Glenrock plant. Since then he has had experience in the Lewiston, Montana, plant as well as at Wichita Falls and at Sapulpa, while that plant was in operation. He was water-treater operator, boiler foreman, fuelman, shift foreman and assistant supervisor before he became superintendent at Lewiston in 1931. In 1941 he became superintendent at the Denver plant.

D. R. JOHNSON



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Care of Rubber Hose Important at This Time

CARE of rubber products, especially hose, is an obligation that workmen in the refining and natural gasoline plants cannot ignore. How to give these products longer life has been outlined by William S. Richardson of the Industrial Products Division, The B. F. Goodrich Company, in the February number of Factory Management and Maintenance.

The following are parts of the article that have application to the manufacturing plants within the petroleum industry. First are the facts of rubber life as follows:

"Exposure to sunlight deteriorates natural rubber rapidly and is a frequent cause of breakdowns. Therefore it is important that all rubber products—hose, belts, tires, clothing, etc.—be protected from the sun's rays wherever possible.

"Oil, gasoline, grease, and other products with a petroleum or vegetable oil content are harmful to rubber. These materials destroy rubber by eating into it, by rotting it, causing it to swell and lose its elasticity. Whenever possible to avoid it, oils and greases should not be permitted to come in contact with rubber; if it does happen, the rubber should be cleaned and washed as quickly as possible. There are special solutions for this purpose, but even soap and water are useful.

"Abrasion destroys rubber, as it does everything else. In many instances it is possible to cut down frictional wear by checking all equipment over which rubber travels or which it touches, and making needed adjustments.

"Heavy overloads on tires, conveyor belts, transmission belts, and other products cause strains that break down rubber and fabric, shorten their life. This condition can be avoided by strict observance of loading rules and closely adhering to operating regulations provided with the equipment, or easily obtainable.

"Excessive heat or cold also destroys certain important properties of rubber, especially when a rubber product is subjected to severe heat (exceeding 150 degrees Fahrenheit.)

"Constant bending and flexing tend to shorten the life of many industrial rubber products, especially those not specifically designed for such service.

"Capacity to stretch and return to its original shape is the most valuable property of rubber. It must be remembered that a rubber article which is kept under constant tension is much more susceptible to deterioration than the same rubber article at rest. For example, a hose if closed at the end and constantly full of water or air at high pressure will have only a fraction of the life of a similar piece of hose that is used intermittently.

"Rubber is not completely waterproof—contrary to common belief. Hose and belting constantly drenched with water gradually absorb some of it. The moisture penetrates to the cotton reinforcement and sometimes mildew and rotting can destroy the structure."

The essential steps in proper care and use of water hose was given as follows:

"1. Avoid bending, kinking, dragging over rough surfaces of any kind.

"2. Do not kink to shut off flow of water. Always use valve or shutoff nozzle.

"3. Whenever possible supply a reel on which to wind the hose when not in use.

"4. Store water hose in a protected place away from the sun and weather.

"5. Drain water from hose when not in use to avoid penetration of water to the reinforcing cotton fabric.

"6. Do not use at higher working pressure than recommended by the manufacturer.

"7. When hose must be used under excessive pressures, avoid constant use. Periodic use for short periods will give longer life.

"8. Connection to valve should be arranged so that hose hangs down. A constant bend near the coupling, with weight of hose putting tension on rubber, will seriously shorten hose life."

Recommendations for proper use of the air hose included:

"1. Buy the best grade of hose available, with the tube recommended to resist oil and heat and the cover to resist abrasion.

"2. Hold exposure to heat and oil to minimum.

"3. Select hose with some firmness of body to help resist kinking and cracking.

"4. Keep compressors in good repair, particularly the after-coolers.

"5. Keep the hose cover clean and free from oil; prevent disintegration.

"6. Use care in handling air hose. Do not drag it over sharp objects.

"7. Do not permit hose to catch on equipment; it may be subjected to a severe stress when an attempt is made to release it.

"8. Do not use hose as a tow rope to

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BRADEN STEEL

pull compressors or tools of any kind.

"9. High-pressure-type couplings having clamps that fasten onto the shank as well as to the hose give the best results.

"10. When rubber hose is not in use, store it in a cool, dry place."

There were 15 points given in regard to steam hose:

"1. Use hose only within recommended maximum temperatures and corresponding steam pressures. Cotton fails sooner than rubber. Consequently a six-ply hose lasts longer than five-ply.

"2. Select a hose of a diameter satisfactory to resist the pressure involved. A small-diameter hose will stand more pressure than a large-diameter hose with the same number of plies.

"3. Use the shortest practical length.

"4. Hose with one end open will stand higher pressure than when both ends are closed.

"5. Guard against hose becoming plugged, since pressure can back up and cause undue strain or failure of fabric plies in carcass.

"6. Use saturated steam when pressure conditions are the same, in preference to superheated steam, since the latter is more damaging to hose.

"7. Prevent alternate freezing and heating.

"8. Avoid frequent flexing and bending.

"9. Use hose with extra cover thickness, if it is subject to excessive abrasion conditions such as dragging over concrete floors, or against the sharp edges of machinery or equipment.

"10. When hose is used for wash-up service in packing plants, creameries, ice cream plants, or oil refineries, use a hose designed for that service.

"11. One end of the hose should be open when steam pressure is turned off; quick condensation may cause tube to pull away from the carcass.

"12. Select couplings suitable for the pressures involved. It is desirable to use a type of coupling for steam hose that can be retightened after it has been in service for a time.

"13. Avoid exposure of hose to excessive heat; if unavoidable, use hose with a woven asbestos cover.

"14. Hose can be wire-wound to resist external wear and as an additional safeguard against expansion and excessive bending.

"15. When used for wash-up service and exposed to fats, grease, and oil, wash outside cover daily. Drain hot water from hose after using."

How to select, use and protect fire hose was thus outlined:

"1. When a choice can be made, purchase hose with close-woven jackets, which wear longer and give fuller protection from abrasion.

"2. Buy hose made with flat cure, since it folds naturally and places no strain on hose tube when racked or coiled. Since fire hose is racked or coiled 90 percent of its life, flat curing actually lengthens the life of the hose 20 to 50 percent. It also permits handling with less effort than round-cured hose.

"3. If stored in racks, use as few folds as possible and change position periodically to relieve strain on rubber tube at same point.

"4. Dry hose after use, to avoid mildew.

"5. When new hose is received, remove from packing cases as soon as possible, and loosen coils to relieve strain on rubber tubes.

"6. Run water through unused hose periodically to retard oxidation of the lining. Be sure to drain and dry thoroughly after such operation.

"7. If exposed to oil or grease while in service, be sure hose is cleaned off before stored.

"8. If the jacket is subjected to gasoline, wash thoroughly as fumes can loosen the adhesion of the tube from the cotton jacket.

"9. Check standpipe valve at intervals to eliminate leakage of water into the hose, especially in winter when freezing may occur.

"10. Care must be taken to protect jackets from coming in contact with acids. If contact occurs, wipe or brush off lightly, as soon as discovered, with a 5 percent solution of washing soda, followed by a thorough washing with plain water."

Instructions concerning couplings for all types of hose was:

"Couplings must be properly attached because suitable care in this respect will add to the life of the hose, and make it safer to use. Compressed air and steam are very dangerous, and many accidents occur because of improperly attached couplings and fittings. Precautions that apply to hose couplings include the following:

"1. Remove all burrs or sharp points from stem of coupling or nipple. End of stem should be rounded off so as not to cut the tube.

"2. Coat the inside of the hose with

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Faster, more effective action inside the tubes, and faster action between tubes. That's what the powerful new Roto Tube Cleaner equipped with a one-man operating air valve gives you. This time and labor-saving cleaner enables the operator quickly to turn the air on and off entirely by himself, not only eliminating a helper but also the inevitable signalling delays between every tube cleaned. Now, when increased refinery production is so vital and skilled help so scarce, every refinery engineer owes it to himself to write for details of the new time and labor-saving Roto.

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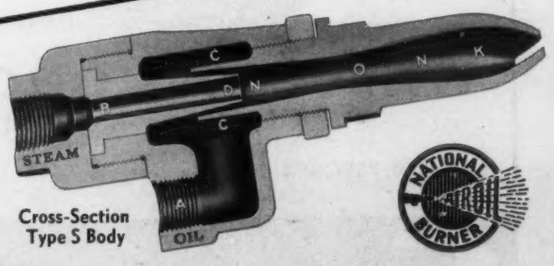

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soap solution or rubber cement. Apply it also to the shank before inserting, but do not let the cement dry before inserting. Never use oil or grease.

"3. If the stem of the coupling is too large to enter the hose, do not cut away any portion of the tube to make the hole larger.

"4. When attaching couplings of seat or socket type, cut hose as square as possible, to allow end to seat properly.

"5. Do not drive a coupling into hose with a hammer or mallet. Force it in evenly and squarely after lubricant has been applied. Place the coupling in a vice and push the hose over the sleeve.

"6. Use clamps of the proper size and draw them up tight. It is preferable to leave a small space between the lips of the clamp for future taking up of the clamp.

☆ ☆ DIGEST OF ☆ ☆ FOREIGN LITERATURE

HEINZ HEINEMANN

Lubricating Oils and Wax

A method for the measuring of the lubrication effect by means of friction is described by E. Heidebroek in Angewandte Chemie, 54, 85. Two steel plates are moved against each other with the lubricant placed between them. The movement is suddenly stopped and the period which is required to part the contact under given conditions is determined. A formula which gives a characteristic value for each oil is derived. The apparatus can also be used for viscosity determinations.

French patent 840,980 to Ruhrchemie A.G. concerns the resistance of synthetic lubricating oils. The lubricating oils which have been obtained from cracking products by polymerization with aluminum chloride or similar catalysts are improved in their oxygen resistance by an after treatment with aluminum chloride at temperatures of above 140° and preferably of 180°.

A reconditioning of used lubricating oils by plant products is described in British Patent 537,082, issued to Celec Corporation, Ltd. Plants with fleshy leaves are extracted with an alkaline solution like aqueous Na_2CO_3 and the resulting gel is added to the used lubricating oil. Copper or nickel salts or acid are then added to the gel to coagulate it and the mixture is filtrated.

The importance of the aromatic part of light lubricating oil fractions is studied by E. A. Robinzon (J. applied chem. U.S.S.R. 13, 1852; Chem. Abstr. 35, 20, 7166). Fractions of Karachukhur crude oil, boiling from 200 to 400° contain from 12-14 percent aromatic hydrocarbons while the same fractions from Balakhany crude contain from 30-32 percent aromatic hydrocarbons. The aromatic hydrocarbons from both crude oils (b. 160-200° at 1mm) are free from aromatics with long side chains of the fatty acid series such as cetylbenzene and cetylhydindene as well as cetylnaphthalene and diacetylnaphthalene. The above finding was confirmed by sulfonation which yielded in all cases H_2SO_4 soluble sulfonic acids.

The average composition of aromatic hydrocarbons present in the fraction boiling from 130 to 160° at 1mm corresponds either to the bicyclic aromatics with an aliphatic side chain or to monocyclic hydrocarbons with naphthene cycles in the side chain. When both types are present the average composition of the aromatic part corresponds to aromatic hydrocarbons with two aromatic cycles, one naphthene ring and an aliphatic chain.

Aromatic hydrocarbons contained in the fraction boiling from 190 to 220° at 1mm correspond to aromatics with three aromatic rings and a corresponding length of the aliphatic side chain or two aromatic and one naphthene ring and one aliphatic side chain, or two aromatic and two naphthene cycles and one paraffin side chain. Hydrocarbons having in their molecule one aromatic ring, one naphthene ring and a paraffinic chain have different consts. from those of aromatics present in Karachukhur and Balakhary crudes. Evidently the average composition of the oils under investigation corresponds to aromatics with a great number of rings while hydrocarbons representing naphthalene with cycles in the chain of the type of cyclopentyl- and dicyclopentylnaphthalene have considerable higher consts. than the aromatics of the original fractions. This permits assuming that this

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One large oil company ran comparative tests, pumping hot oil at 900° and pump running at 3600 R.P.M. The COLMONOY coated pump sleeves ran for 2400 hours, against 360 hours for other sleeves.

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Part of his letter read as follows:

We have a particular problem presented by the packing sleeve of a hot oil pump in a nearby refinery. The last sleeve was faced with COLMONOY and lasted three to four times as long as the original faced sleeve. We have been asked to bid on a set of sleeves faced with COLMONOY No. 6.

You can save time, increase production and cut costs by coating all parts subject to excessive corrosion and abrasion with COLMONOY — pump sleeves, wash pipes, plungers, rings and many other parts of oil producing equipment.

COLMONOY will keep new parts on the job longer — and many worn out, discarded parts, when COLMONOY coated, will outwear and out-perform new, uncoated parts many times over.

Write Today for Full Information

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BUHL BUILDING, DETROIT, MICH.

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NEW YORK CITY, BLASDELL, N. Y., CHICAGO, TULSA, WHITTIER, CALIF.
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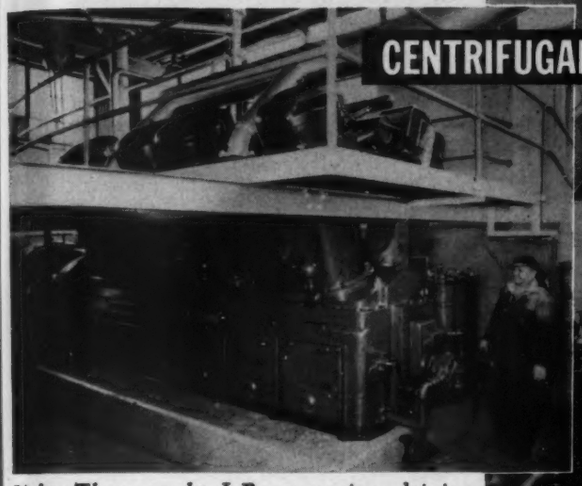
COLMONOY
Hard Surfacing Alloys and Overlay Metals

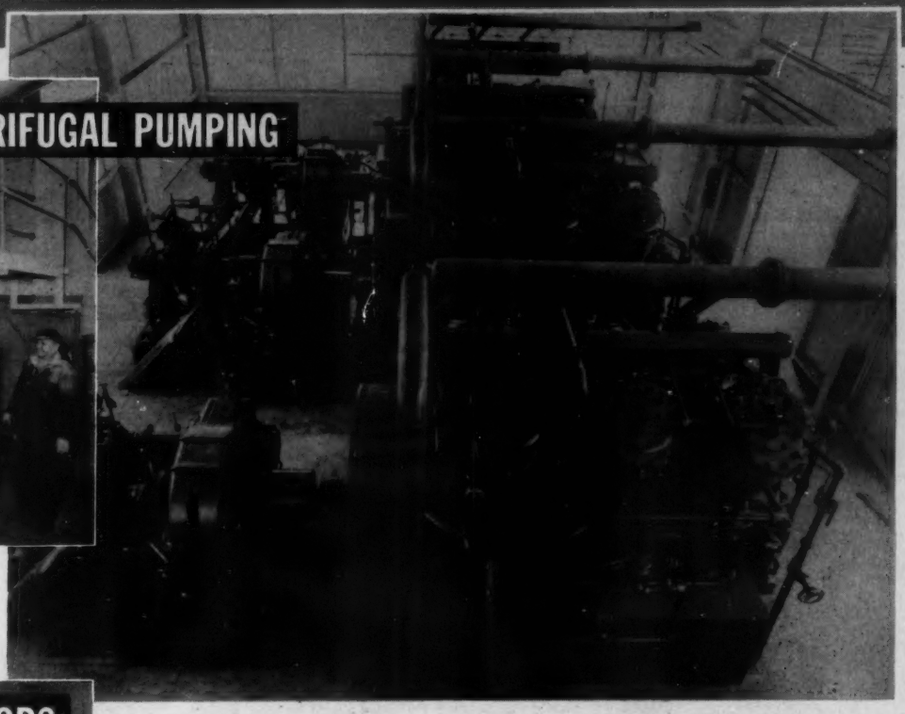
I-R 4-CYCLE GAS-ENGINE POWER

the first "V-Angle" design . . . introduced in 1931

for oil field — pipe line — refinery



CENTRIFUGAL PUMPING



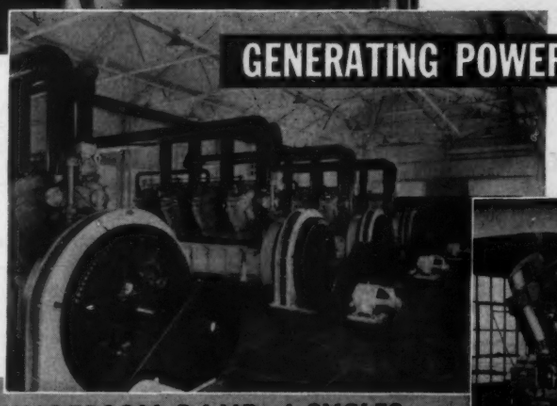
Right: Three 275-hp I-R gas engines driving Ingersoll-Rand centrifugal pipe-line pumps through speed-up gears. Above: 650-hp gas engine direct-connected to I-R centrifugal single-stage pump.

PUMPING WITH RECIPROCATORS

Three 185-hp gas engines geared to reciprocating pumps.

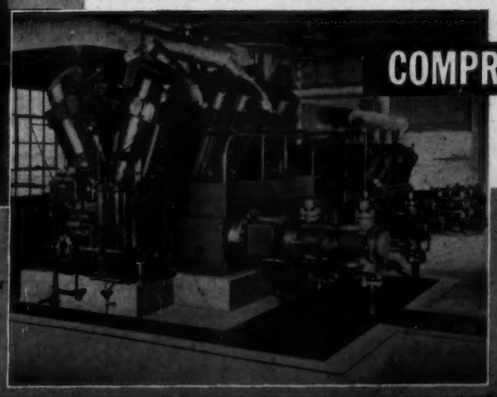
In designing the VG lines of 4-cycle gas-engine units, Ingersoll-Rand engineers made sure that every one would have the stamina, reserve, flexibility, simplicity, and accessibility to meet the severe demands of the oil industry. That they have done their job well is evidenced by the hundreds of such units now in all kinds of refinery and oil-field service...in all parts of the world. Here are some typical examples of the variety of services.

GENERATING POWER



Three 370-hp gas-engine generator units.

COMPRESSING GAS



650- and 300-hp gas-engine compressor units in recycling service.

SIZES OF INGERSOLL-RAND 4-CYCLES

GAS ENGINES—185 to 800 hp
GAS-DRIVEN COMPRESSORS—75 to 800 hp
DIESEL ENGINES—225 to 600 hp
DIESEL-DRIVEN COMPRESSOR UNITS—65 to 275 hp

Pumps • Compressors • Blowers
Condensers • Steam Jets • Rock Drills
Pneumatic Tools

Ingersoll-Rand

11 BROADWAY, NEW YORK, N. Y.

WELDOLETS·

TRADE MARKS · REG. U. S. PAT. OFF.

THREDOLETS

. . . Welded Outlets for Piping . . .

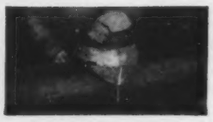
How to Save Time, Materials and Labor in Making Right-Angle Branch Pipe Outlets

BECAUSE Bonney WeldOlets, ThredOlets and Socket-End WeldOlets eliminate all cutting and threading of the main pipe, they will save time, material and labor in making right-angle branch pipe outlets. Their installation is extremely simple and easy as shown in the illustrations.

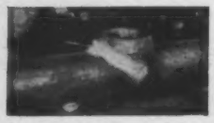
WELDOLET

THREDOLET

Socket-End WELDOLET



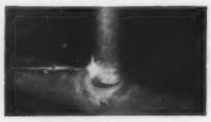
1—Select the position of the outlet. Rub the fitting over the pipe several times to remove scale, dirt—mark center lines—tack into position.



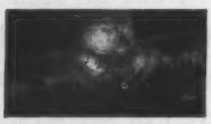
2—Tacking is done in enough places to insure its desired position. No clamps are necessary. Then weld, following and filling the bevel along the base of the fitting. A junction of full pipe strength is assured.

3—When the outlet of the fitting exceeds 2", weld the fitting to the main pipe and then remove the button—in two sections. Where the outlet is smaller than 2" or under unusual conditions on larger sizes, the fitting should be used as a templet and the hole cut in the main pipe first.

4—After the fitting is installed on the main pipe and the button removed, the inside of the joint is in full view for inspection. Interior inspection is impossible with welded pipe-to-pipe intersections, welding tees, saddles, etc. Icicles, scale and excess welding metal are eliminated when WeldOlets, ThredOlets or Socket-End WeldOlets are used. They are removed with the button.



5—The end of the branch pipe is then beveled at 45° and welded to the outlet of the WeldOlet. If ThredOlets are used, the threaded branch pipe, is screwed into the outlet of the fitting—or, if Socket-End WeldOlets are used, the branch pipe is slipped into the fitting and an ordinary weld made around the top of it.



6—The job is then complete. Note the trim, mechanical appearance. External as well as interior obstructions are eliminated, saving materials and reducing the weight of the entire system.

WeldOlets, ThredOlets and Socket-End WeldOlets form clean, unobstructed branch connections. Their funnel-shaped intake aperture reduces turbulence and friction. No templets are required, nor is it necessary to do complicated cutting and fitting.

Standard stock fittings are of drop forged steel (outlets from ¼" to 12") in size-to-size and reducing sizes. For special applications, or where unusual conditions exist, they can be supplied in Toncan Iron, wrought iron, brass, Monel, Everdur, etc. and in sizes up to 24" x 24".

They are suitable for every type of piping installation and for all commonly used pressures and temperatures.

Your local distributor will be glad to tell you the complete story about savings which can be effected, or write for Bulletin WT29—TODAY.

Bulletin WT29—Get your copy of this 20 page book NOW. It gives complete information about WeldOlets, ThredOlets and Socket-End WeldOlets.

BONNEY FORGE & TOOL WORKS

FORGED FITTINGS DIVISION

ALLENTOWN, PA.

type of hydrocarbon, the molecule of which contains simultaneously aromatic and naphthene cycles and also the paraffin chain, corresponds properly to the mean compound of the aromatic part of the crude oil, provided the total of cycles is not below three. The same conclusions are arrived at with the fraction boiling from 205 to 210° at .5mm on the basis of consts. of hydrocarbons separated by Rossini from Mid-Continent crude oils and they are close to Karachukhur and Balakhany oils. The consts. of monocyclic and bicyclic aromatics with long paraffin chains are very different from the aromatic part of the lubricating oil fractions of Grozny mixed and asphalt-base crudes and of Surukhany, Emba, Balakhany crude oils while bicyclic aromatics with shorter chains or monocyclic aromatics with napthene cycles (side chains) are close to the aromatic hydrocarbons of the original fractions.

British Patent 531,120 to Edeleanu G.m.b.H. treats the dewaxing of hydrocarbon oils. The oils are diluted with a mixture of liquid SO_2 and an auxiliary solvent which increases the solvent power of the liquid sulfurdioxide. Precooled benzol or chloroform serve this purpose.

Analysis

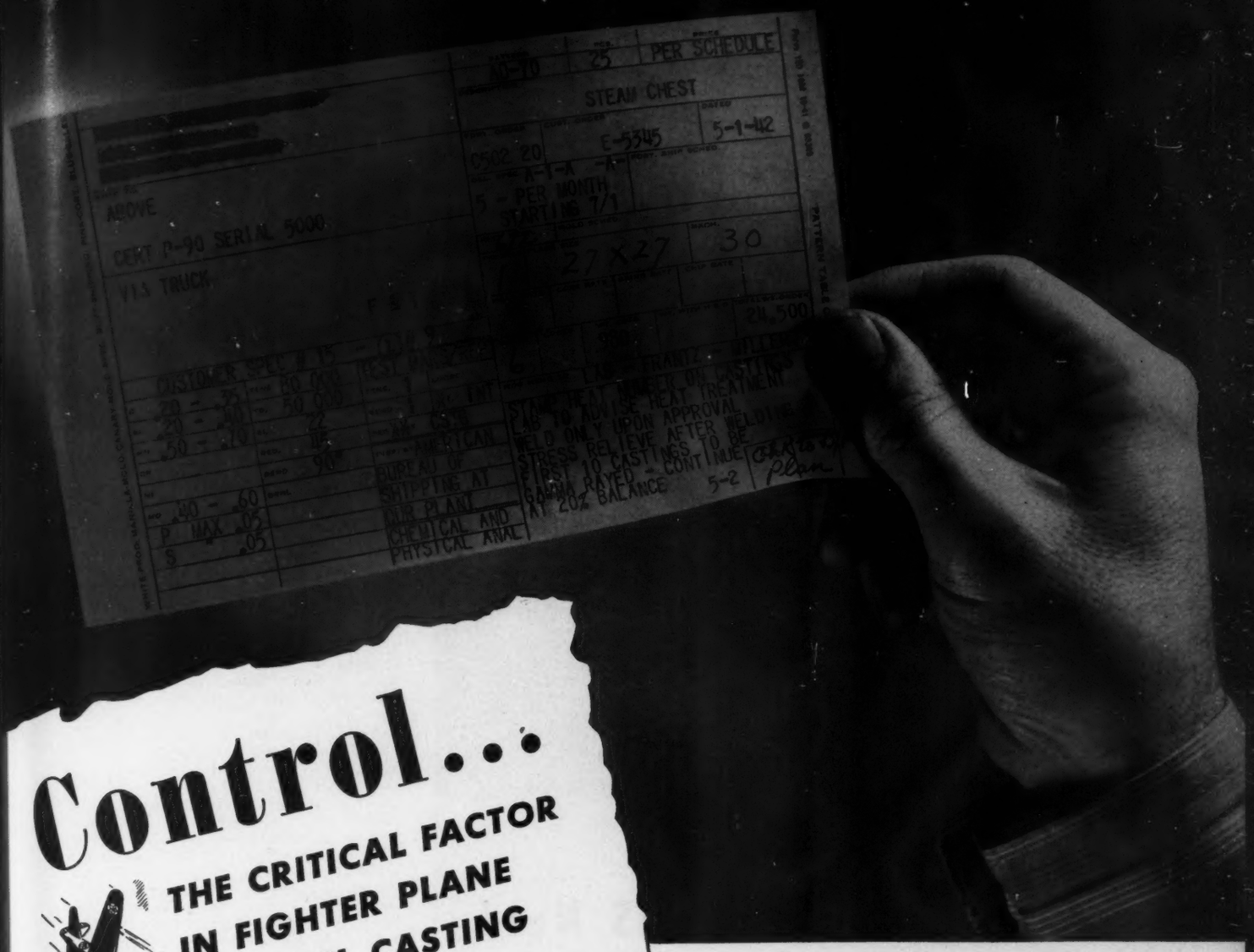
The separation of different fractions from hydrocarbon mixtures is effected by a method based on crystallization. (British Patent 525,388 to N. V. de Bataafsche petroleum Maatschapij). The fractions of different paraffin content are separated from hydrocarbon mixtures by precipitation with and crystallization from solvents with different solvent power for these fractions.

The reactions of fuels with air-oxygen mixtures is investigated by H. Hock in Techn. Mitteilungen Gemeinschaftsorgan der Technik 32, No. 278. For studying the autoxydation of fuels tetralin and cyclohexane were investigated. About 20 percent of primary oxydation products are obtained which can be isolated in the vacuum. The secondary reactions of the obtained peroxides which are responsible for gum formation could be studied. The investigation was extended to chain olefins. These are generally hard to oxydize. The middle fractions of a cracked gasoline formed peroxides in experiments while the total gasoline fraction did not show such reaction. Inhibitors boiling above 150° prevented the oxydation. Not only the gum formation but also the corrosion effect of fuels can be explained by this peroxide formation.

Refining, Cracking and Hydrogenation

Refining of hydrocarbon oils and derivatives is described in British Patent 534,970 to E. A. Ocon. The naphtha distilled from cracked petroleum products is partly oxydized and then mixed with a cracked residue. The part of the mixture boiling below gasoline range is conducted over a dehydrating agent like zinc oxide, aluminum oxide, silica and particularly copper - uraniumphosphate and an alkaline oxide at 200-540°.

A process to refine hydrocarbons with phosphoric acid in the vapor phase is the subject of N. V. de Bataafsche Petroleum Maatschpij' British patent 529,-873. Hydrocarbons are freed from nitrogenous bases by treatment with dilute



Control...

THE CRITICAL FACTOR IN FIGHTER PLANE OR STEEL CASTING

THOUSANDS of horsepower speed the fighter plane to combat . . . batteries of machine guns and cannon aim it for the kill . . . yet powerful motors and heavy armament cannot win a single "dog-fight" unless *control* instruments function perfectly.

This simple principle of control as the critical factor governs all operations at Lebanon—beginning with the writing of shop orders. These orders are not treated as routine detail. They are made into comprehensive "working plans" through which each department in the plant gains a thorough understanding of the customer's requirements.

Lebanon shop orders cover chemical and physical specifications . . . heat treatment . . . pattern equipment . . . delivery requirements . . . inspection—both by customer's representatives and by Gamma and X-Ray . . . sample castings for dimensional checking by customer or foundry . . . customer's requests for test blocks or coupons as well as all specific customer instructions . . . preference ratings . . . estimated or actual casting weights. These orders replace chance with *control.*

Control . . . and control again . . . control wherever possible . . . that is the premium Lebanon pays for the exceptional integrity, soundness and quality of Circle (L) Castings . . . the castings which safeguard such reputations as those of Westinghouse and Jones & Lamson.

Lebanon metallurgists are studying future applications for alloy and carbon steel castings of controlled quality . . . and are ready to discuss significant developments with forward looking organizations.

LEBANON STEEL FOUNDRY · LEBANON, PENNA.

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON *Stainless and Special Alloy* **STEEL CASTINGS**

CIRCLE L

sulfuric acid at elevated temperatures. After that aqueous phosphoric acid (containing up to 30 percent H_3PO_4) is finely distributed in the heated hydrocarbon by spraying or the like and is converted into a sludge which passes through the reaction zone. .05 to 3 g of phosphoric acid are used per liter of hydrocarbon. The sludge is later hydrolysed and the acid recycled.

A process for the manufacture of high-octane gasoline is disclosed in French Patent 843,789 to International Hydrogenation Patents. Gasoline present in the crude oil is distilled off and the residue is fractionated into a middle oil (300-350°) and a heavy oil which eventually may be asphalt-like. The middle oil is cracked after preceeding hydrogenation in presence of suitable catalysts like Al_2O_3, bleaching earths, bauxite, oxides or sulfides of metals of the fifth to eighths group, halides and organic halides. The heavy oil is hydrogenated after removal of the lubricating oil at 300 to 400 at with catalysts like tungsten or molybdenum sulfides. The hydrogen-poor oils from the cracking of the middle oil and the hydrogen rich oils from the hydrogenation of the heavy oil are united and cracked at a higher temperature than the original middle oil.

Ignition and Combustion of Diesel Fuels

"Means of Improving the Ignition Quality of Diesel Fuels" treated by E. M. Nygaard, G. S. Crandall and H. G. Berger (J. of the Institute of Petroleum 27, No. 214,348). Though the majority of straight-run fuels excepting those derived from highly aromatic or naphthenic crudes, possess an adequate ignition quality for present day requirements in high-speed diesel engines, it appears necessary to aim at a raising of the cetane number of stocks having only about 25 cetane number, considering the increasing demand for such straight-run stocks in the production of high anti-knock fuels for gasoline engines and the growing markets for deisel fuels of high ignition quality. The problems for the refiner are: (a) the raising of fuels of poor ignition quality (25 cetane number) to 50 cetane number. (b) The increasing of fuels of slightly sustandard ignition quality (40-49 cet. no.) to 50 cet. no. (c) the production of premium fuels of higher than 50 cet. no. The problems (b) and (c) may be solved by the use of small amounts of suitable materials added to the fuels. The problem (a) is comparable to raising a 24-octane gasoline to 68-octane gasoline with tetraethyl lead. This would be impractical and uneconomical. Solvent treating or a combination of solvent treating and use of fuel additives appears possible for the solution of this problem.

As the fuel characteristics demanded for high-speed diesel engines are opposed to those demanded for automibile and airplane engines, any cracking process designed to produce fuels of high octane number would tend to yield diesel fuels of poor ignition quality.

An additive for the improvement of the cetane number should be relatively insoluble in water and chemically stable in its presence, sufficiently soluble in the fuel and stable in the fuel against variations of storage conditions, causing no sedimentation. A table showing the relative effects of various ignition additives is given. The most effective materials are thionitrites, an inexpensive and fairly effective accelerator is elementary sulfur. The most useful treatments for diesel fuels are solvent treating and treating with aluminum chloride. Effectiveness and costs of different treating methods are compared. A list of the patent literature is given.

A paper on investigations concerning the combustion of diesel fuels is published by W. Wilke in Motortechnische Zeit. 39, 43. Gas oil and a hydrogenation product of coal are tested in a test motor. Compression ratio and the type of fuel introduction were changed and the ignition delay, pressure increase and flue-gas temperature were measured under these conditions. It is shown that the ignition delay alone is in many cases insufficient for the fuel evaluation and that the perssure increases has to be considered. However, ignition delay and pressure increase are usually related to each other.

Potentiometer Indicators

The Foxboro Company, Foxboro, Massachusetts, has a bulletin restricted to its complete line of potentiometer temperature indicators and indicating resistance thermometers.

The instruments described include single-point and multiple-point models, models equipped with selective key-switches for as many as 52 contact points, as well as the popular portable models. Single-range and double-range dials are shown in full-size reproductions and a complete list of standard ranges is given. Constructional features of the instruments are shown and described, many of these features being exclusive in Foxboro design.

Cycling plant—designed and constructed by PETROLEUM ENGINEERING, INC.

The UNITED NATIONS Need More 100 OCTANE Gasoline—

. . . made from the products of Natural Gasoline and Cycling Plants

We are pioneers in the design and construction of plants of High Efficiency extraction and close fractionation.

These plants produce Liquid Propane and Butane . . . Iso Butane and Iso Pentane . . . Recovery Gasoline . . . Natural and Vapor . . . Benzene and Toluene . . . Other Special Products

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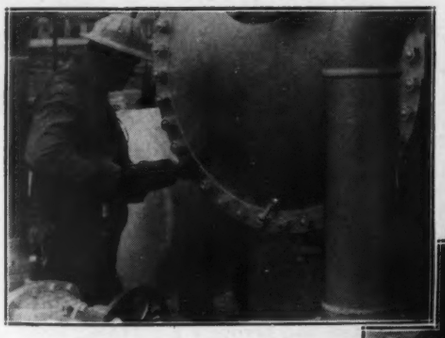
Tulsa, Oklahoma **Houston, Texas**

CP WRENCHES REDUCE MAINTENANCE TIME

↑ **TAKING OFF THESE BIG NUTS** with hand wrenches would be a slow job — the Chicago Pneumatic 375-R Wrench (Impact Type) runs them off in a jiffy, and puts them on again just as quickly. Handles bolts, nuts, lag screws, etc., up to 1¾" bolt size.



← **THE MORE NUTS THERE ARE** on a condenser or reaction chamber, the greater the time saving with this CP 365-RP Pneumatic Wrench (Impact Type). Short overall length, tapered nose, lack of vibration make the 365-RP easy to handle; for nuts up to 1¼" size.

FOR NUTS, BOLTS, LAG SCREWS → up to ¾" bolt size, the CP 360-RS has no superior. CP Pneumatic Wrenches are simple in design, sturdily built. Slow speed motors, absence of springs and gears in driving unit and minimum number of parts insure low maintenance.

SPEED UP CLEANING OF PRESSURE VESSELS, HEAT EXCHANGERS

Handle Nuts, Bolts Up to 1¾" Bolt Sizes

HOUSTON (CP) — With the rapidly increasing use of CP Pneumatic Wrenches, refineries in this section are materially reducing the time required to clean pressure vessels, heat exchangers and other bolted equipment. A maintenance man can run off ten nuts in less than a minute with a CP Pneumatic Wrench — a job that would require at least ten times as long with a hand wrench. Being reversible, these CP wrenches effect an equal time-saving in nut or bolt application.

There are five models of these time-saving CP Wrenches, handling nuts, bolts, lag screws, etc., up to 1¾" bolt size. Write to Chicago Pneumatic for all data.

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Closing Date Extended to July 1, 1942

For rules of contest write to: Educational Director, Compressed Air Institute, East Orange, N. J.

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DIVISION OF PETROLEUM CHEMISTRY OF THE AMERICAN CHEMICAL SOCIETY

Abstracts of Papers Presented at Memphis, Tennessee, April 20 to 24, 1942

Substitute Fuels, a War Economy of World Dimension

GUSTAV EGLOFF AND P. M. VAN ARSDELL
Universal Oil Products Company, Research Laboratories, Chicago

With the United Nations in the possession of 90 per cent of the world's oil, the fuel situation for the Axis-controlled nations has involved the use of many substitute motor fuels. Hydrogenation of coal by the Bergius and carbon monoxide by the Fischer-Tropsch process has been responsible for 43 per cent of the oil used by Germany for war purposes. The other substitute fuels, compressed gases, alcohol; wood- and coal-burning automobiles, trucks, buses and boats; shale, and miscellaneous fuels have not been as important in military usage as the liquid fuels, but they are used exclusively by the civilian population since no liquid fuel is available. Altogether the substitute fuels and petroleum have made 122,700,000 barrels of fuel available to the Axis countries.

At the end of 1941 it was estimated that there were a total of 107,225 compressed gas vehicles which released approximately 2,553,000 barrels of liquid fuels, and a maximum of 373,143 producer gas vehicles in use in Europe, which saved about 7,780,000 barrels of oil fuel. Approximately 13,200,000 barrels of benzol and alcohol were produced on the European continent in the same period and 233,000 barrels of shale oil also had been produced. Sweden and Spain planned to produce greater quantities of shale oil from their undeveloped resources.

The cataloguing of the other substitutes shows that man has availed himself of animal, vegetable, and mineral products to run his motor vehicles on all the continents of the world.

BUILT-
RIGHT
Again we are happy to extend greetings to the Natural Gasoline Industry, which has been our privilege to serve for so many years.
Tulsa Boiler & Machinery Co.
WEST TWENTY-FIRST STREET & UNION AVENUE TULSA, OKLAHOMA

Influence of Sulfur Compounds Upon Octane Number and Lead Susceptibility of Gasolines

JULIAN G. RYAN
Shell Oil Company, Wood River, Ill.

Antiknock characteristics of gasolines are impaired by the presence of sulfur compounds to an extent dependent upon hydrocarbon structure and sulfur type. Susceptibility to tetraethyl lead as affected by structure of sulfur compounds has been investigated quantitatively. A relation which is independent of hydrocarbon composition has been established between concentration of various sulfur types and lead susceptibility. This mathematical expression permits accurate evaluation from group-sulfur analyses of the improvement obtainable by partial or complete desulfurization, the effect of gasoline-sweetening methods, and the effect of blending stocks of similar hydrocarbon composition but different sulfur contents.

The effect of sulfur compounds upon octane number in the absence of tetraethyl lead varies with size and structure of the hydrocarbon portion of the molecule as well as the sulfur type.

Some Additional Acids from California Petroleum

GEORGE WASH, WM. O. NEY, JR., W. CROUCH, AND H. L. LOCHTE
Department of Chemistry, University of Texas

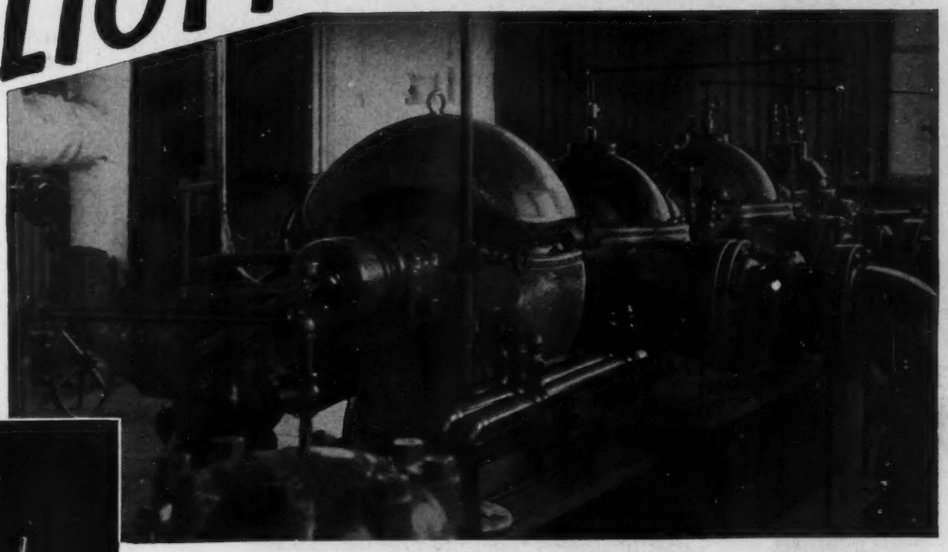
In continuation of research on petroleum acids from California straight-run gasoline and kerosene *n*-octanoic, *n*-nonanoic, 2-methylcyclopentanecarboxylic, 3-methylcyclopentylacetic, and 2, 3-dimethylcyclopentylacetic acids were isolated and identified. This increases to six the number of naphthenic acids isolated from California petroleum by this group of workers.

Isolation of Sulfur Compounds From a California Straight-Run Gasoline

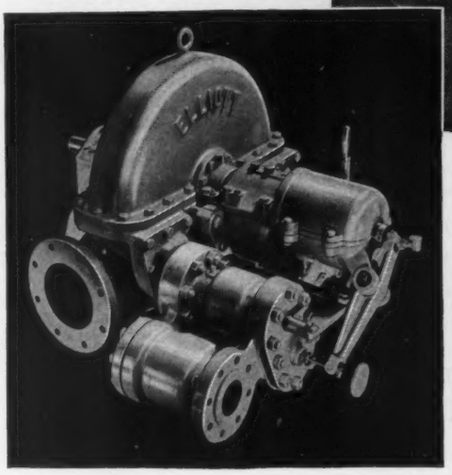
O. L. POLLY, A. C. BYRNS, AND W. E. BRADLEY
Union Oil Company of California

The present investigation was undertaken to examine a product obtained by treating high-sulfur naphtha with anhydrous aluminum chloride at ordinary temperature. Aluminum chloride was found to remove sulfur compounds practically quantitatively in the form of

. . . so they said: "OK - make it ELLIOTT TURBINES!"



An Elliott 197-hp. turbine driving three pumps in tandem, in a natural gasoline plant. There are several tandem drives like this in this plant.



THE PLANT SUPERINTENDENT INSISTED—said that when it comes to turbines, proven operating results counted more than competitive bids. Pointed out that it was his job to keep things going and show a profit in plant operation, and he didn't want any trouble with his pump drives. Words to that effect.

So in this natural gasoline plant, eight Elliott turbines are doing a sweet job of driving various pumps, singly and in tandem, and are consistently demonstrating those qualities of dependability that have put thousands of them at work in refineries.

There is no sentiment involved in the liking of refinery engineers for Elliott turbines, but it is very real, for all that. Refinery engineers feel that their Elliott turbines make life just a bit easier for them, and make plant operation and profits just a bit more certain. That's all there is to it.

But there is plenty to the turbine itself. Why not ask for the Elliott Turbine Bulletin, and check on it.

ELLIOTT COMPANY

Steam Turbine Dept., **JEANNETTE, PA.**

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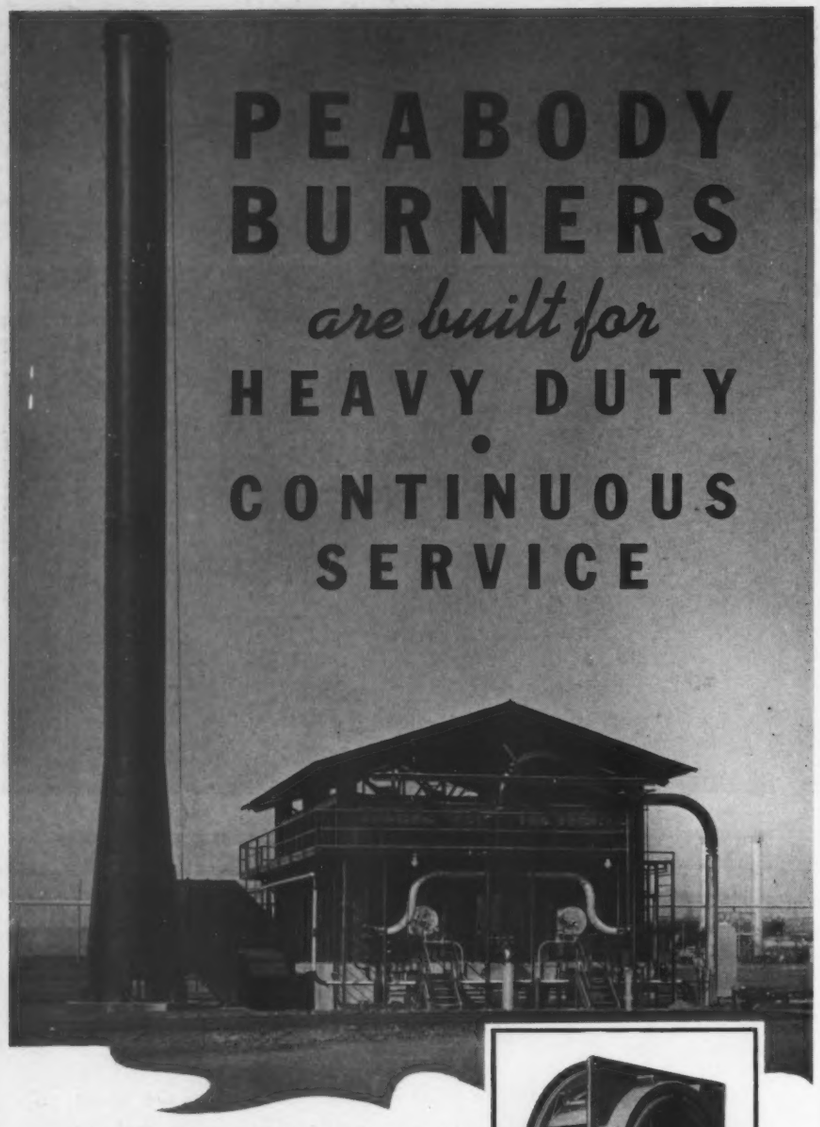

THE PEABODY TYPE MU Combined Gas and Oil Burner is especially built for the gruelling service that refinery burners encounter. It is right for this work, because it has been developed through experience gained under long, hard, uninterrupted service.

We provide them with extra heavy cast parts; design them to preserve the strength of the furnace wall when installed; equip them with atomizers that consume the kinds of oil used by refiners; make the gas ring quickly removable and replaceable without disturbing the oil atomizer at work; furnish them for natural or forced draft operation.

We will supply you with burners to meet any load or heating requirement. The thousands in successful use are their best recommendation. Send us your specifications and let us advise the correct Peabody Burner for your needs.

PEABODY ENGINEERING CORPORATION
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a heavy fluid sludge, which was readily separated from the naphtha. Hydrolysis of the sludge liberated an oil which analyzed 20 weight percent sulfur. Seventy per cent of the oil boiled in the original naphtha range. Close-cut fractions of this material yielded several thiopanes identical with those previously reported in the literature. Improved methods of segregating individual sulfur compounds are reported.

Oxidation Characteristics of Lubricating Oils. The Relation Between Stability and Chemical Composition

G. H. von Fuchs and H. Diamond
Shell Oil Company, Wood River, Ill.

Analysis of rate curves obtained by measurement of oxygen absorption has elucidated the effect of basic composition, methods of processing, and addition agents on the stability of oils. Oxidation characteristics are strongly influenced by interaction phenomena between different types of components. Saturated hydrocarbons in an oil have a tendency to rapid autocatalytic oxidation whereas aromatic compounds act as antioxidants by a mechanism of autoretardation. The balance between these opposing effects is strongly dependent on the reaction temperature. Under given conditions of temperature and metal catalysis maximum stability is observed at an intermediate (optimum) aromaticity. Autoretardation differs from the action of conventional inhibitors. Reactions involved in the formation of saponifiable material (free, combined, and potential acids) may account for most of the oxygen absorbed by an oil. Results can be correlated with oil deterioration and lacquer depositions in engine tests.

Surface Consistency Characteristics of Asphalts

E. C. Knowles and F. C. McCoy
The Texas Company, Beacon, N. Y.

The need for studying the surface consistency characteristics of asphalts, as well as the bulk flow properties, is pointed out. A modification of the A.S.T.M. asphalt penetration method which has been used to investigate consistency characteristics of asphalt surfaces ranging in thickness from 0.04 to 0.30 cm. is described.

The modified procedure is based upon the load in grams required to force the A.S.T.M. needle into the asphalt to a given depth in a constant time. This procedure avoids several shortcomings of the A.S.T.M. penetration procedure and has been identified as constant depth penetration.

Data are given to illustrate the application of constant depth penetration measurements to show the progressive increase of hardness of roofing asphalt in the accelerated weathering test. Data are also given to illustrate application of the method to the measurement of the effect of various storage conditions on surface consistency of asphalt, and from this work a storage test was set up at 125°F. whereby the tendency of asphalts from various sources to undergo surface hardening was determined.

The conclusion is reached that certain properties of asphalt surfaces can be studied by application of constant depth penetration measurements, and that the results supplement information current-

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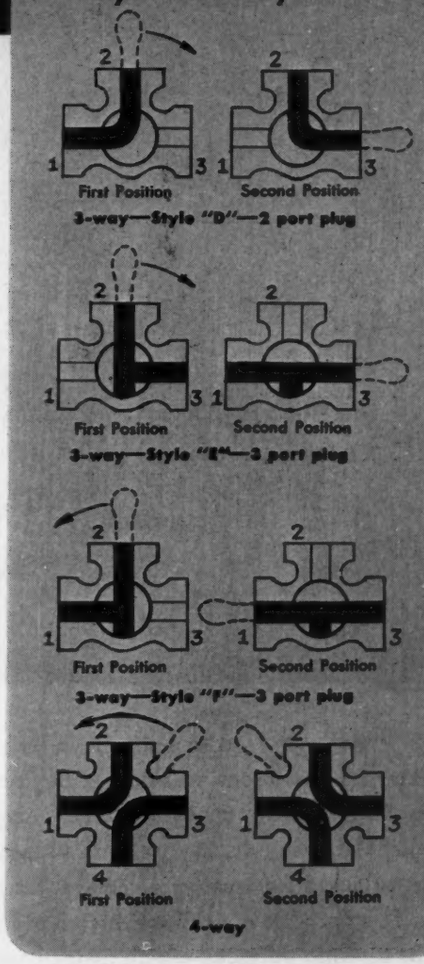

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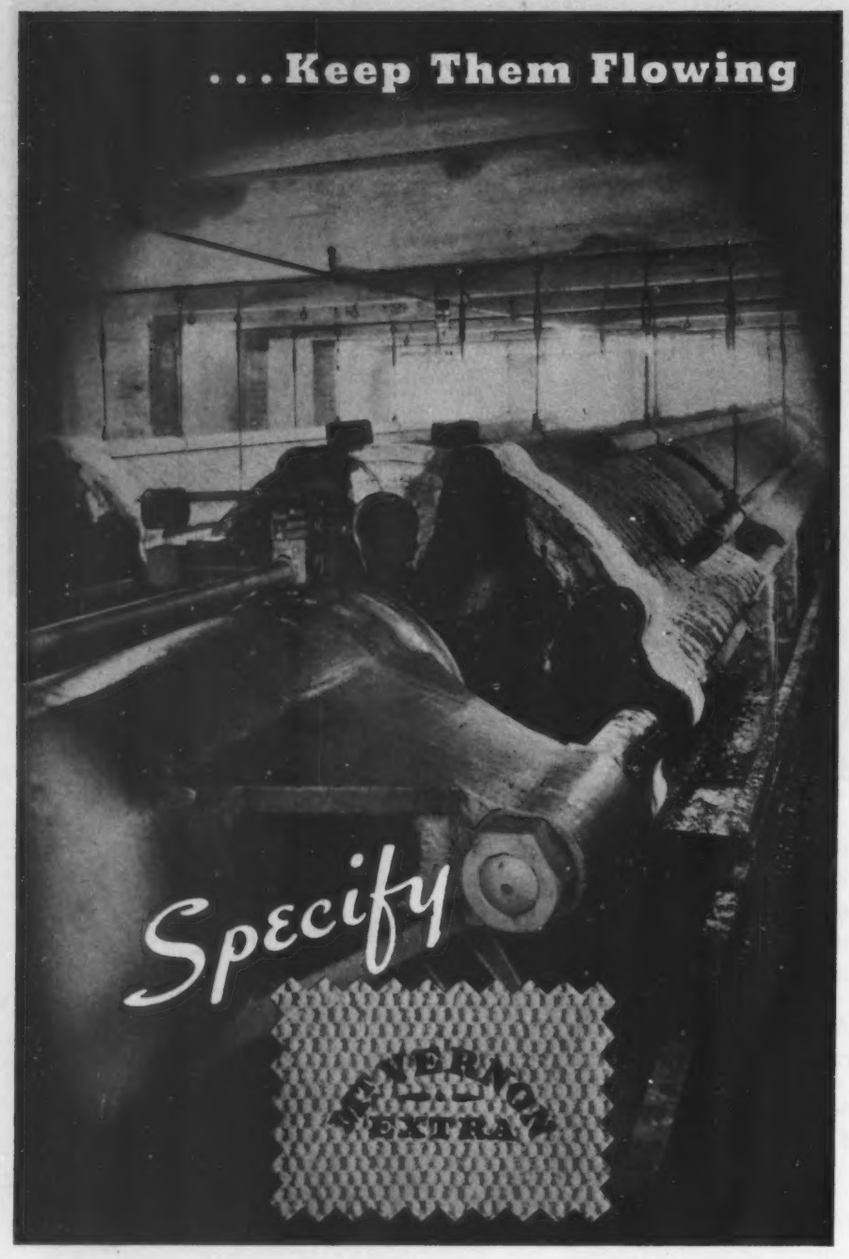

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ly obtained by bulk flow consistency measurements.

Alkenes, Alkadienes, Alkapolyenes, Their Source and Production

GUSTAV EGLOFF, GEORGE HULLA, AND JACQUE C. MORRELL
Universal Oil Products Company, Research Laboratories, Chicago

Petroleum is the logical resource for an increased U. S. production of unsaturated hydrocarbons and substances obtainable therefrom, including aviation gasoline (neohexane, trimethylpentane, tetraethyl lead), explosives, natural rubber substitutes, war gases, pharmaceuticals, solvents, lubricants, plastics, and resins.

The principal production methods are: (1) thermal, (2) catalytic, and (3) electrical treatments of substantially individual alkanes, alkenes, cyclanes, and cyclenes, (4) cracking of petroleum, shale, coal, tars, and fats, (5) catalytic dehydrogenation of alkanes and alkenes, (6) polymerization of alkenes and alkadienes, (7) hydropolymerization of alkynes, and (8) the Fischer-Tropsch synthesis. Special processes include: (1) isomerization, (2) hydrogenation, (3) alkylation, and (4) depolymerization of hydrocarbons, and (5-13) interrelated decompositions of alkanols, alkenols, alkapolyenols, alkanediols, ethers, carboxylic acids, esters, quaternary ammonium hydroxides, and organometallic compounds. The alkapolyenes are generally obtained from animal and plant oils or by dehydration of alkapolyenols.

Determination of Thiosulfate in Used Doctor Solution

KARL UHRIG AND HARRY LEVIN
The Texas Company, Beacon, N. Y.

A method is described for determining thiosulfate in used doctor solution. It is based on the observation that carbon dioxide precipitates the lead and simultaneously converts any sulfite present to bisulfite which subsequently is bound to formaldehyde to render it inactive toward iodine. Under these conditions, thiosulfate is titrated alone.

Determination of Olefins in C_3 and C_4 Hydrocarbons

B. R. STANERSON AND HARRY LEVIN
The Texas Company, Beacon, N. Y.

A method is described for determining olefin content of C_3 and C_4 hydrocarbons by direct titration of sample condensed in cold chloroform. Bromine in glacial acetic acid is used for titration. The method has given satisfactory results on synthetic blends covering the complete range of unsaturation and is particularly suited for routine plant control purposes because of its simplicity and rapidity.

Hydrogen sulfide, mercaptans, and 1,3-butadiene interfere and must be removed before analysis.

Molecular Weights of Viscous Hydrocarbon Oils

ALFRED E. HIRSCHLER

Molecular weights of lubricant fractions have been correlated with kinematic viscosities at 100° and 210°F., using a modified Keith and Roess chart, and with densities at 25°C. and the 210°F. viscosities. By combining these two charts a correlation between these four physical constants is developed whereby any two may be used to estimate values of the other two. Based on

this chart, a simple equation has been developed for calculating the molecular weight from viscosity data, applicable to oils with viscosity indices between —50 and 140. The application of these charts to published data on lubricant fractions of petroleum and to synthetic hydrocarbons is discussed, and it is shown that previously proposed correlations of molecular weights with viscosity data are unsatisfactory for oils covering a wide range of viscosity-temperature characteristics.

Critical States of Two-Component Paraffin Hydrocarbon Systems

F. Drew Mayfield
Phillips Petroleum Company, Bartlesville, Oklahoma

Empirical correlations of literature data are presented by means of which critical temperatures, pressures, and compositions of two-component normal paraffin hydrocarbon systems can be predicted. Values calculated by means of these correlations are compared with existing published data on ten systems. Disregarding positive and negative signs for the errors, and excluding two systems, the average error for the calculated pressures is 13 pounds per square inch or 1.3 per cent, and the average error for the calculated temperatures is 6.4°F.

Studies of the Physical Properties of Alicyclic Hydrocarbons. II. Boiling Points of Monocyclic Hydrocarbons

Gustav Egloff and Robert C. Kuder
Universal Oil Products Company, Research Laboratories, Chicago

From a correlative study of over 300 alicyclic hydrocarbons not containing fused rings generalizations have been made concerning the variation of boiling point with structure. The following aspects are considered: branching of side chains, number of side chains, relative position of side chains, *cis-trans* isomerism, effect of introduction of double bonds (classified as to type), position of double bonds with respect to side chains, conjugation of double bonds, and effect of introduction of triple bonds. Where possible the generalizations made for alicyclic boiling points are compared with those already developed for aliphatic boiling points and alicyclic molal volumes.

Thirty Years of Petroleum Research

B. T. Brooks

The present war compels us to take stock of our strength. The present position of the American petroleum industry is largely the result of thirty years of research and engineering backed by understanding management.

In 1940 as compared with 1914, we produced five times as much crude, 13 times as much gasoline, had 19 times the tonnage of tankers, and had 20 times the number of research workers.

A great change in the character of the research personnel and the nature of researches undertaken is noted. Distinctions between practical men and scientists are no longer made. The industry has gone scientific from top to bottom and this is one of the most significant changes in the management and technical personnel of the industry.

Exchange of technical information

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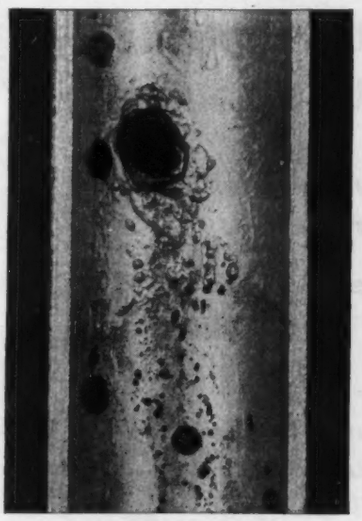

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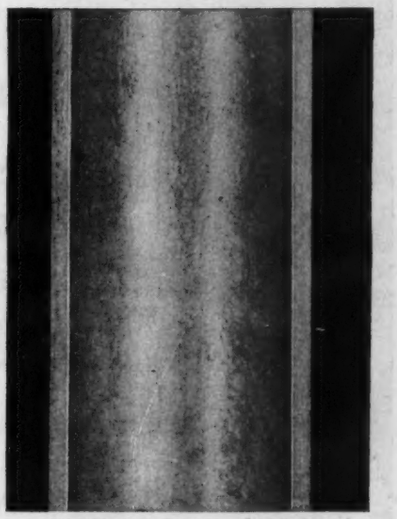

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and publication of results has been the general rule. This has been possible up to now by reason of the protection afforded by our patent system. Serious weakening or radical change in our patent system would greatly change this.

The vast changes and present technical position of the industry has been due mainly to the stimulus of the development of cracking processes, the effect of the first World War on the industry, and a great increase in the research and technical personnel on the staffs of all major companies.

Adequate quantities of synthetic rubber can be made only by the petroleum industry. The responsibility is with the government. This may be another case of too little and too late.

☆ PLANT ACTIVITIES ☆

Cooperative ventures came into the refinery construction program last month. These instances of several concerns combining resources so units can be built to provide critical war materials, chiefly butadiene and 100-octane-aviation gasoline, are the outgrowth of the announcement last month of the contracts being considered by the Office of the Petroleum Coordinator for National Defense.

Both integrated companies and independent refining units are included in the joint efforts, whose primary objective is to make special products.

Largest of these ventures was Neches Butane Products Company, a Delaware corporation, formed by The Atlantic Refining Company, Gulf Oil Corporation, Magnolia Petroleum Company, The Pure Oil Company and The Texas Company. The plant, which is being financed by Defense Plant Corporation, is scheduled to cost $75,000,000. It will operate on special cuts from the refining plants of the several companies and will be the major unit in the program of providing the requirements from petroleum for the production of 700,000 tons of synthetic rubber of the Buna type, along with another 100,000 tons of butyl and neoprene types.

In the South Texas area, Aviation Gasoline Corporation has been formed and will build facilities for production of 3500 barrels daily of 100-octane-aviation gasoline. Pontiac Refining Corporation will operate the unit. Isomerization and alkylation plants are among the processes to be constructed.

The company will get 2500 barrels daily of butane and isobutane from several cycling plants as one part of the feed stock for the alkylation unit. The plant is due to cost in excess of $6,000,000.

North Texas

Seven independent refining companies in North Texas and Southern Oklahoma have formed Cooperative Refiners, Inc., which will construct a plant for production of 100-octane-aviation gasoline. The concerns involved are Bell Oil & Gas Company, Ben Franklin Refining Company, Cosco Refining Company, LaSalle Refining Company, Rock Island Refining Company, Panhandle Refining Company and the W. T. Wagoner estate. The plant is being financed by Defense Plants Corporation and the output will be sold to Defense Supplies Corporation.

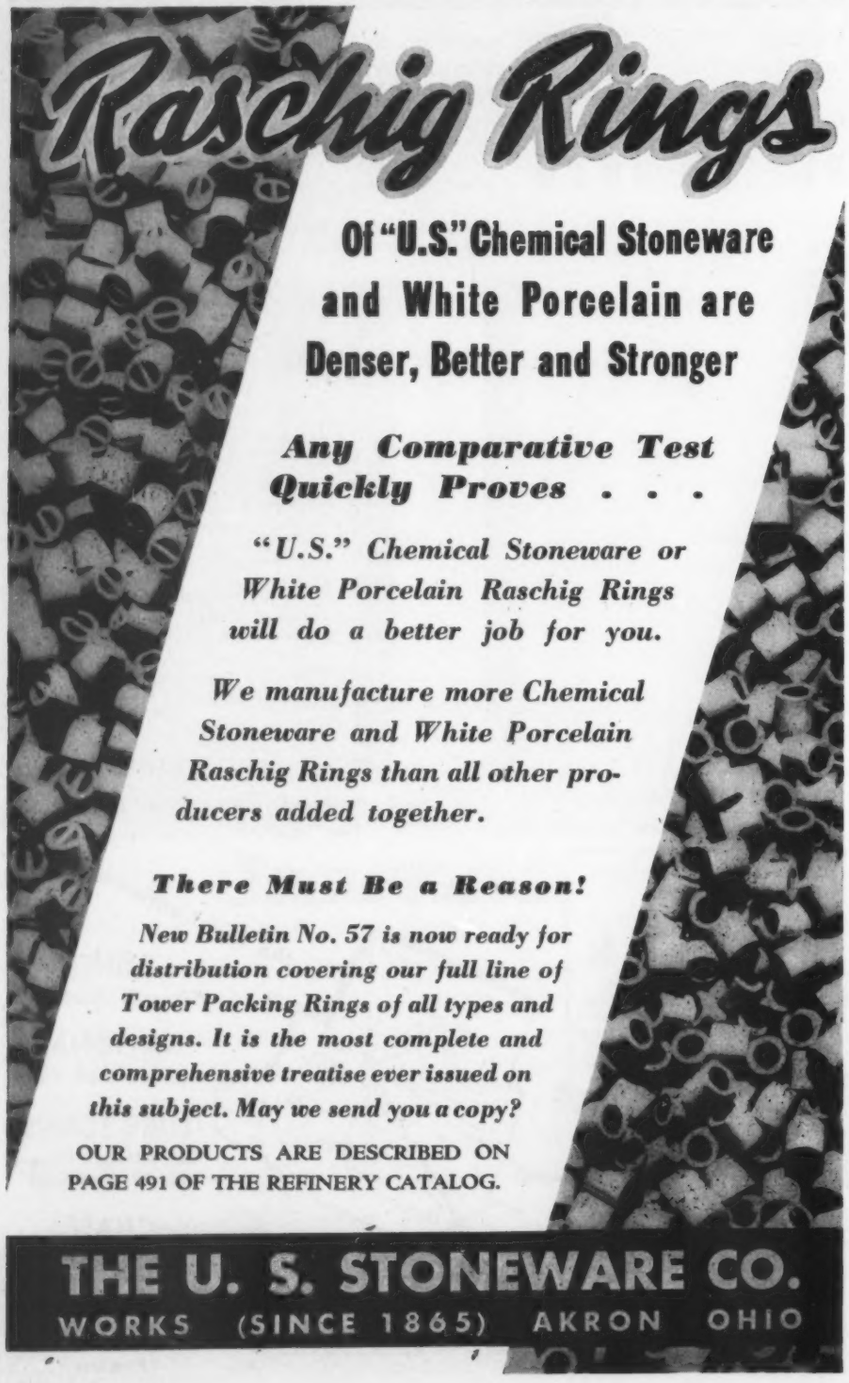
Semi-processed naphthas and gases will be furnished from the member concerns and processed into 3500 barrels daily of 100-octane-aviation gasoline. Cost of the plant is estimated at $8,500,000.

Another cooperative venture is under consideration for the refining area around Chicago.

In July the national program for synthetic rubber was increased by 100,000 tons per year. Now under consideration is a building program which will provide 700,000 tons of Buna rubber and 100,000 tons of Butyl rubber and neoprene.

Construction of new facilities for 35,000 barrels of gasoline output daily in Mexico is under consideration. Because of restrictions on equipment from the United States authorities of Mexico have given the outline of plans to OPC for consideration.

The Chicago office and midwestern warehouse of the Metallizing Company of America has been moved to 1330 West Congress Street, Chicago.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This wider range of complete compatibility has been gained with no sacrifice of effectiveness and no change in the inspection of the finished lubricant. Like Santopoid A, Santopoid S is stable and non-corrosive at operating temperatures. It does not separate from the lubricant or stratify, and no salts are precipitated. E. P. lubricants containing 10% Santopoid S will serve equally well in transmissions, differentials or hypoids, and they will stand up under long mileage and severe operating conditions without appreciable change in viscosity or load-carrying ability.

Santopoid S is an additive complying with Federal Government Specification VV-L-761, and the proper Bureau of Standards certificate to this effect will be forwarded to those interested. For samples of Santopoid S and the 24-page technical bulletin which gives full details on both Santopoids A and S, write: MONSANTO CHEMICAL COMPANY, Petroleum Chemicals Department, St. Louis, Missouri.

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☆ ☆ ☆

Certain restrictions on the use of lubricant additives contained in Recommendation No. 40, released March 19 by the Office of the Petroleum Coordinator, should be noted as they apply to additives supplied by Monsanto: (1) Santolubes 261 and 303 are both metallic, detergent-disperser type additives and should not be used in passenger car lubricants. (2) Santopoids A and S should not be used in transmissions, particularly in passenger cars, under the order banning use of all-purpose, extreme pressure additives except for such gears as require them. (3) None of the additives offered by Monsanto, however, are affected by the strict limitations on products requiring cresol since none are manufactured from cresol.

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SCIENCE AND TECHNOLOGY

Abstracts prepared in co-operation with the

REFINER AND NATURAL GASOLINE MANUFACTURER

by

THE LESLIE LABORATORIES
Traver Road, Ann Arbor, Mich.

under the supervision of
DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Vapor Pressures and Critical Constants of Isobutene,

J. A. BEATTIE, H. G. INGERSOLL AND W. H. STOCKMAYER, *Jour. Amer. Chem. Soc.* **64** (1942) pp. 546-8.

The vapor pressure of isobutene was measured from 30 to 125° C. The equation $\log_{10} p(\text{atm.}) = 4.3759_2 - (1163.34/T)$ represents the results. The vapor pressure calculated at 0° C. from this equation is in good agreement with that measured by Lamb and Roper. The critical constants of isobutene as determined by the compressibility method are: $t_c = 144.73 \pm 0.05°$ C.; $p_c = 39.48 \pm 0.05$ normal atmosphere; $v_c = 0.240$ liter/mole or 4.28 cc./gram; $d_c = 4.17$ mole/liter, or 0.234 grams/cc. The uncertainty in the critical volume and density is 1%. The critical pressure and temperature as given are in excellent agreement with those determined by Benedict, who used the disappearance of the meniscus method.

Effect of Pressure on Enthalpy of Pentane, Heptane, and Isooctane,

E. R. GILLILAND AND M. D. PAREKH, *Ind. & Eng. Chem.* **34** (1942) pp. 360-2.

In an earlier paper one of the authors presented data on the effect of pressure on the enthalpy of benzene. The present article gives similar results of work on n-heptane, n-pentane, and isooctane. The experimental apparatus used was the same as that previously described with a few minor exceptions. Data were obtained on the isothermal enthalpy changes with pressure for the three hydrocarbons at pressures between 200 and 2900 pounds per square inch and at temperatures between 330° and 660° K., respectively. The data are compared with the results obtained by other investigators. They are presented in some detail in tabular and graphical form.

Molal Volume Nomographs for Aliphatic Hydrocarbons,

D. S. DAVIS, *Ind. & Eng. Chem.* **34** (1942) p. 351.

A nomograph is presented for the molal volume of aliphatic hydrocarbons. It is based on the equations: $V = a(n + 4.4)^c - 37.00$, and $\log (V + 37.00) = At + B'$. In these equations a is characteristic of the branching, B' depends upon the series, and c and A are characteristic of the unsaturation. One nomograph presented holds closely for sixty-three aliphatic hydrocarbons, and Figure 2 covers forty-three compounds reliably.

Molecular Volume of Liquid Alkanes at Corresponding Temperatures,

G. EGLOFF AND R. C. KUDER, *Ind. & Eng. Chem.* **34** (1942) pp. 372-3.

To overcome the faults of the melting and boiling points as corresponding temperatures, the authors made a study of molecular volume at a series of exactly equal reduced temperatures. They found that the molecular volume is an additive function at any reduced temperature between the melting points and the boiling points of the normal alkanes from ethane to octane, inclusive, with no complications from the alternating factor of melting point. The equations, $V = a + bn$, $a = 9.43 + 10.24\ T_R$, $b = 14.912 + 1.765\ T_R + 10.00\ T_R^2$ reproduce the data with an average percentage deviation of about 0.12 percent. Data on the reduced melting point and boiling point on critical temperatures, on molecular volume, and on the effect of reduced temperature on Equation 1 are given in the article. A bibliography of 14 references is included.

Viscosity - Temperature Function of Liquids,

A. H. NISSAN, *Phil. Mag.* **32** (1941) pp. 441-56.

When the viscosity of the normal paraffins is plotted against a variable which is the ratio of the absolute boiling point under atmospheric pressure to the absolute temperature of measurement, a single curve is obtained for all members. This holds for all the normal paraffins from C_4 to C_{18} over the range in which they exist as liquids. The constants of the equation connecting these quantities are calculated. The observed values were found to fit the general curve closely. The mean value of the viscosities for the normal paraffins at their boiling point is 0.200 centipoises. A special graphic method was devised with an artificial temperature scale which gives a straight-line curve for the normal paraffins. All liquids having a viscosity-temperature relationship that is a straight line follow the same law. The findings of the author are discussed in relationship to the general theory of the viscosity of liquids.

Ethylene-Ethane and Propylene-Propane Equilibria,

G. B. KISTIAKOWSKY AND A. GORDON NICKLE, *J. Chem. Phys.* **10** (1942) pp. 78-9, 146.

Equilibrium constants were determined in atmospheres for the system ethylene-ethane. These are: for 380° C., 4.04×10^{-5}, at 450° C., 5.16×10^{-4}. For the system propylene-propane, at 310° C. the value is 3.68×10^{-5}, and at 375° C., 5.25×10^{-4}. These are in good agreement with values calculated from measurements at 82° C. The heats of the two reactions are 34,000 cal./mole at 415°, and 30,800 Cal./mole at 343° C.

The Compressibility of and an Equation of State for Gaseous Isobutene,

J. A. BEATTIE, H. G. INGERSOLL AND W. H. STOCKMAYER, *Jour. Amer. Chem. Soc.* **64** (1942) pp. 548-50.

The authors have previously reported data on the compressibilities of methane, ethane, propane, n-butane, and n-heptane, and have described the apparatus used and the method followed in making the determination. Their work has now been extended to isobutene. Measurements of the compressibility of gaseous isobutene are reported from 150 to 275° C. and from a density of 1.0 to 9.0 moles/liter. The maximum pressure used was 250 atmospheres. In a glass-lined bomb isobutene did not polymerize seriously during a ten-hour period until a temperature of 275° C. was reached. The constants for an equation of state of gaseous isobutene were determined from the data up to the critical density; and the values of the second virial coefficients determined from the experimental data are given from 150 to 275° C.

Chemical Compositions And Reactions

Type Analysis of Hydrocarbon Oils,

R. M. DEANESLY AND L. T. CARLETON, *Ind. & Eng. Chem., Anal. Ed.* **14** (1942) pp. 220-26.

The purpose of the work reported was to attempt to provide a more accurate and widely applicable system of analysis for the type analysis of hydrocarbon oils containing aromatics, unsaturated naphthenes, and paraffins. This is based on a more strict definition of the terms expressing composition and by the development of new correlations through values of these terms can be determined by physical tests. The general procedure of analysis includes the evaluation of aromaticity or unsaturation of the sample, and determination of the structure of the sample when completely saturated. The method of evaluation of aromaticity is first described, making use of the Lorenz-Lorenz equation for molecular refraction. Methods of procedure are described in some detail. The authors feel that the method is consistent with the known data on pure hydrocarbons and hydrocarbon oils, and appears to be equally applicable to straight-run and cracked products, or to synthetic oils over all the range in which requisite measurements are possible. Although an absolute check could not be made, it is estimated that the errors are relatively small and random. Analyses made are self-consistent, while those made by the Waterman method, the only other generally used for the same purpose, or not.

Determination of Types of Sulfur Compounds in Petroleum Distillates,

J. S. BALL, *U. S. Bur. Mines, Rept. Invests.* **3591** (1942) 60 pp.

The report describes a system for the analysis of petroleum distillates for various types of sulfur compounds including H_2S, free sulfur, mercaptans, disulfides, aliphatic sulfides, aromatic sulfides and thiophenes. The procedure is strictly applicable only to straight-run distillates of the gasoline range, although it is of some value with other distillates. Difficulties arise because the aromatic sulfur compounds, or other compounds in which the reactivity of the sulfur atom is subordinated by long carbon chains or heavy radicals do not react actively. With increase in the carbon-sulfur ratio, the sulfur compounds show less reactivity peculiar to the type of sulfur compound.

Thermal Reaction of Ethylene with Acetylene,

E. A. NARAGON, R. E. BURK, AND H. P. LANKELMA, *Ind. & Eng. Chem.* **34** (1942) pp. 355-8.

The investigation was concerned with the study of the reaction between ethylene and acetylene as it pertains to the formation of butadiene and also to liquid hydrocarbons that may be formed from butadiene as an intermediate. Earlier works of Burk, Baldwin, and Whitacre have shown that acetylene reacts more readily with ethylene than the latter reacts with itself. In this cross reaction butadiene is the major gaseous product, although the liquid product exceeds the gaseous. Although conditions were chosen to favor the cross reaction, no attempt was made to ascertain the optimum yield of butadiene

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Fig. 1640
"King-clip" Gate Valve
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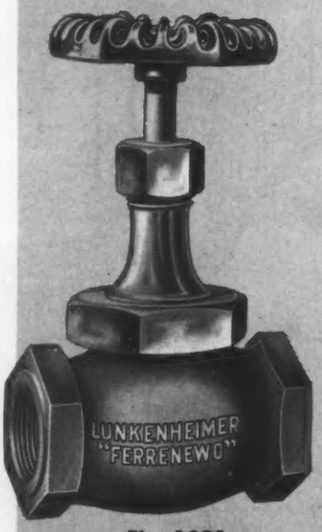

Fig. 1021
"Ferrenewo" Globe Valve
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by this procedure; it was desired principally to establish with certainty the existence of the cross reaction. No butadiene is formed when acetylene reacts with itself under the conditions used in these experiments. Diolefins and aromatics were prominent in the liquid products formed. The experimental procedure used is described in some detail. The synthesis of butadiene was studied in an all Pyrex glass flow system at 610° C. at atmospheric pressure and with short reaction time. Steam was used as a diluent. Special precautions were taken to remove traces of oxygen from the reacting gases. The results show that ethylene and acetylene combine in equimolecular proportions to form butadiene. Side reactions that occur are the dimerization of ethylene and of acetylene. From all these primary products both gaseous and liquid secondary products are formed. A bibliography of 15 references is included.

Manufacture: Processes And Plant

Mobilizing Petroleum Hydrocarbons, G. F. FITZGERALD, *Chem. & Met. Engr.* **49** (1942) pp. 83-87.

The petroleum industry is mobilizing its hydrocarbons for use in high-octane aviation gasoline, synthetic rubbers, toluene, and other products. The 100-octane gasoline situation is reviewed. Last year's output was 45 000 to 50,000 barrels per day, which is more than all the rest of the world produces. Before Pearl Harbor, it was considered that an expansion to 126,000 barrels per day by the end of 1942 would be required. A month later the figure was raised to 180,000 barrels per day. The author notes a potential conflict between high-octane aviation gasoline and the raw materials for synthetic rubber. He discusses the situation as regards butane and isobutane. A chart is presented showing the relationship of processes for the production of aviation gasoline, including those in the natural gasoline industry, and those in the oil refineries, including the various types of cracking and gas recovery. The subjects of synthetic rubber, acetylene, and butadiene, catalytic polymerization, catalytic cracking, and isomerization, are all briefly discussed.

Heat Transfer and Pressure Drop in Heat Exchangers, B. E. SHORT, *Univ. Texas Pub. No. 3819* (1938) 39 pp.

An expression is given by the author by means of which the shell side coefficient of heat transfer can be computed for shell- and tube-type exchanges irrespective of the size and spacing of the tubes, or the type, size and spacing of baffles, or the kind of fluid. An expression is also given by means of which the pressure drop along and across the tubes in baffled tube bundles of heat exchangers can be closely approximated. The work was done on a shell-and-tube exchanger in which 3 forms of baffles were used, and in which the spacing of the baffles and the size and spacing of the tubes were varied.

Industrial Instruments for Measurement and control, T. J. RHODES, *McGraw-Hill Book Company, Inc.,* New York, 1941. 573 pp. Price, $6.00.

This new publication in the "Chemical Engineering Series" of the McGraw-Hill Book Company discusses the theory and describes the design of instruments for measuring, recording and controlling the temperature, pressure, rate of flow, and liquid level. The emphasis is on the theory and fundamental principles of design, rather than on the detailed mechanical design. The mathematical theory of automatic control is given clearly and in some detail. The book fills a much-needed want, and will be found useful to designing and operating engineers.

Column for Stripping Solvents from Extracted Oils, F. H. SMITH, *Ind. & Eng. Chem., Anal. Ed.* **14** (1942) p. 255.

The author describes a stripping column suitable for the removal of traces of solvent from laboratory-extracted oils. Although described in relation to its use for the stripping of solvents from vegetable oils, the apparatus would be applicable to the stripping of solvents from solvent-extracted petroleum oils, either extracts or raffinates.

Distillation in a Wetted-Wall Tower, A. J. SUROWIEC AND C. C. FURNAS, *Trans. Amer. Inst. of Chem. Engrs.* **38** (1942) pp. 53-89.

The authors report the results of an investigation of the rectification of ethyl alcohol-water in a 12-inch column previously used by Taylor, but operated with a wetted-wall but with no packing. The apparatus and its operation are described in some detail. Data are presented comparing the performance of the wetted-wall column and of the same col-

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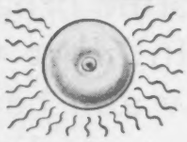

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umn filled with packing. These data indicate that at low rates of liquid flow the transfer coefficient, and hence the efficiency of rectification, was less with packing in the tower than without it. The results of the work indicate that the principal resistance in the tower used was in gas film and not in the liquid film.

Distillation in a Wetted-Wall Column, H. F. JOHNSTONE, *Trans. Amer. Inst. of Chem. Engrs.* **38** (1942) pp. 25-51.

In the investigation reported the effects of composition and fluid velocities on the rate of mass transfer in a small wetted-wall column were studied in the distillation of the four systems benzene-toluene, toluene-ethylene dichloride, ethanol-water, and acetone-chloroform. Also, the apparatus was operated as an absorption column in which pure toluene vapor was absorbed by ethylene dichloride, and ethylene dichloride vapor was absorbed by benzene. The results of the work indicate that not more than ten percent of the total resistance to mass transfer in a wetted-wall column lies in the liquid phase. The observed values for the overall resistance are slightly higher than those predicted from the von Karman-Sherwood theoretical equation, and fall between the values predicted by the correlation of Chilton and Colburn and that of Gilliland and Sherwood. The experimental data for the four systems studied at total reflux and on the absorption of ethylene dichloride vapors by benzene may be represented by the equation:

$$\frac{(\text{H. T. U.})\ ov}{d} = 7.63\ (Re_v)^{0.22}(Sc_v)^{0.67}$$

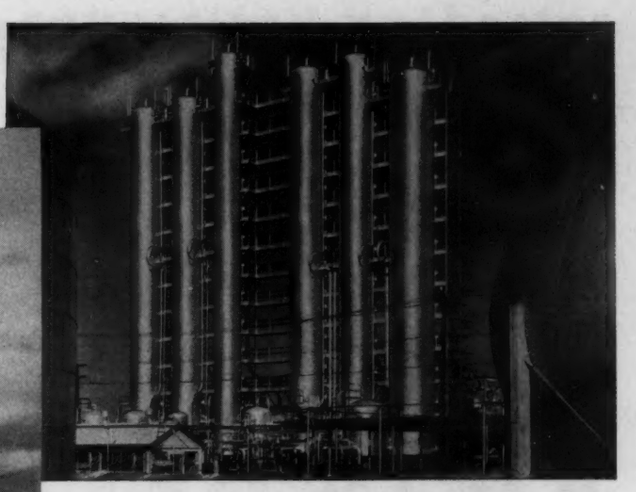
The observed resistance in the liquid phase is considerably lower than would be expected from a theory based on diffusion into a laminar liquid layer. This discrepancy is ascribed to the effects of wave motion and counterflow of the vapor on conditions at the liquid surface. The effect of counter-diffusion of the components, as distinguished from transfer of one component through a second inert and non-diffusing component, is small.

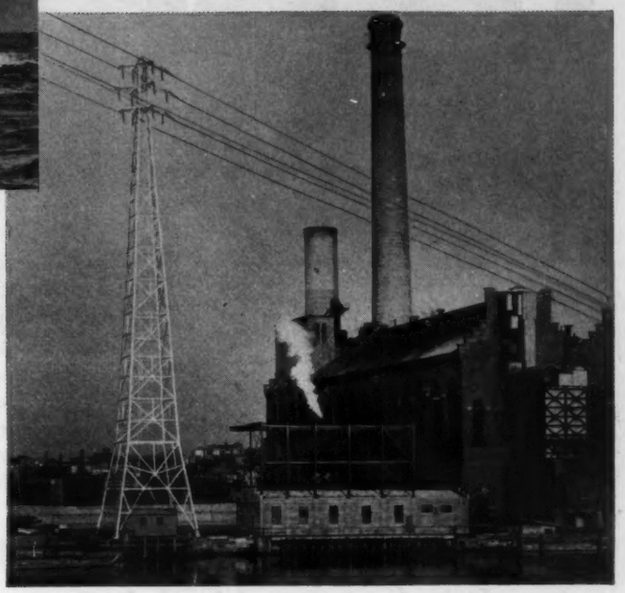
Experimental Study of Individual Transfer Resistances in Countercurrent Liquid-Liquid Extraction, A. P. COLBURN AND D. G. WELSH, *Trans. Amer. Inst. of Chem. Engrs.* **38** (1942) pp. 179-201.

The increased use in recent years of extraction methods in several fields, especially in the petroleum and organic chemical industries, as a means of separation of liquid mixtures, has emphasized the need for dependable design data. The purpose of the study reported was to measure individual film transfer resistances, and to determine the manner in which these resistances vary with flow rates of the two phases in a packed extraction column. By employing a binary system of isobutanol-water and measuring the approach to saturation of the exit streams, individual film transfer units were determined, using a glass column 3-11/16 inches in diameter packed to a depth of 21 inches with ½-inch clay Raschig rings. The flow rates of both phases were systematically varied, and each liquid was made the discontinuous phase. The film transfer unit of the discontinuous phase was found to be practically independent of either flow rate, while the film transfer unit of the continuous phase increased with increased flow of that phase and decreased with increased flow of the discontinuous phase. Both film transfer units were single-line functions of the ratio of the flow rates of the two phases. From these results there was obtained a rational method of interpreting overall transfer data obtained in similar packings, and by this means typical overall data from the literature were separated into H. T. U. values of the separate films. The results indicate that the stream that is large in amount should usually be made the discontinuous phase.

Liquid-Liquid Extraction in Wetted-Wall and Packed Columns, E. W. COMINGS AND S. W. BRIGGS, *Trans. Amer. Inst. of Chem. Engrs.* **38** (1942) pp. 143-177.

Experiments are described using four wetted-wall, countercurrent liquid-liquid extraction columns and four packed columns in which benzene and water were contacted. The compounds extracted were benzoic acid, acetic acid, and aniline. The four columns varied from 0.47 to 7.45 inches in diameter, and from 4.6 to 46.5 inches long. Relatively dilute solutions in water or benzene were used, and special attention was paid to the effect of velocity of each liquid phase on the capacity coefficient. Wetted-wall columns less than 1 inch in diameter gave overall coefficients twice those in packed columns and had capacities per unit area of column section as much as 10 times as great. The velocity of the dispersed phase in the packed column had the greater effect on the overall coefficients and caused the same percentage variation in the resistance in both phases. The velocity of the continuous phase had a smaller effect which was again the same in both phases.





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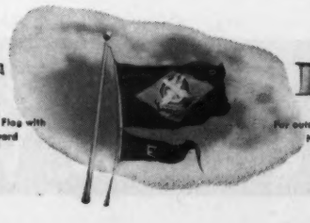

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Overall coefficients for the systems studied in a small packed column can be represented by equations of the form $Ka = aV_D^rVc^s$ where V_D is the superficial velocity of the dispersed phase and Vc, of the continuous phase.

Countercurrent Liquid-Liquid Extraction in a Wetted-Wall Tower, R. E. TREYBAL AND L. T. WORK, *Trans. Amer. Inst. of Chem. Engrs.* **38** (1942) pp. 203-35.

A series of extractions were made using the system acetic acid-water-benzene in a wetted-wall apparatus, wherein aqueous solutions of the acid saturated with benzene formed the film liquid, and benzene solutions of the acid saturated with water formed the core. Measurements of the film thickness, made for laminar flow of the film and turbulent flow of the core during continuous flow of both liquids, show the interfacial velocity of the film to lie between zero and the maximum in the film. Overall extraction coefficients were measured under the flow conditions described, and the variation of the coefficient with the average rates of flow in the core and film relative to the tower wall were studied. The data indicate that the rates of flow of both phases affect the individual extraction coefficients of both film and core, and that neither phase may be said to control. In view of this, it was not possible to break the overall coefficients down into the individual coefficients. The flow of the core liquid influences both individual extraction coefficients, the effect on that of the film being more pronounced at low film rates. The flow of the film liquid may affect both individual extraction coefficients, although the effect on the core is less pronounced than that of the core flow on the film extraction coefficient.

Mixed-Solvent Extraction, A. V. BRANCKER, T. G. HUNTER, AND A. W. NASH, *Jour. Inst. Petr.* **28** (1942) pp. 15-26.

Processes employing two solvents have been divided into two main classes: mixed-solvent processes and double-solvent processes. In mixed-solvent processes both solvents are mutually soluble under the operating conditions — that is, the solvent employed is a homogeneous mixture of the components. In double-solvent processes the two solvents are immiscible or only partly miscible under the operating conditions. The paper is concerned with solvent refining processes employing mixed solvents under conditions at which one solvent is only partly miscible with the stock under the operating conditions, and in which the second solvent is completely miscible both with the first solvent and with the stock under the operating conditions. The work described was undertaken in order to study the effect on extraction brought about by the addition of a completely miscible auxiliary solvent to the primary solvent. As a result of the work it was concluded: (1) at equal solvent/stock ratios better-quality raffinates are obtained with the single solvent than with the mixed solvent. The addition of auxiliary solvent to the principal solvent results in a decrease in the quality of raffinate; (2) at equal solvent/stock ratios better yields of raffinates are obtained with the single solvent than with the mixed solvent; (3) at equal principal solvent/stock ratios an increase in the amount of auxiliary solvent present in the mixed solvent results in a decrease in both quality and yield of raffinate. While the use of an auxiliary solvent of the type considered in a mixed-solvent-extraction process may have certain practical advantages, such as reduction of operating temperature and improvement of phase separation, the general effect is to increase the solvent power of the solvent at the expense of selectivity. This gives rise to a decrease in yield and decrease in quality of resulting raffinates.

Practical Methods for Storing Volatile Liquids, D. E. LARSON, *Trans. Amer. Inst. of Chem. Engrs.* **38** (1942) pp. 1-23.

On account of the expansion in various directions in petroleum and chemical industries many engineers are facing for the first time the necessity of planning facilities for the storage of volatile liquid products in large quantities. Available data on this subject are meager. The purpose of the author's paper is to present practical data that will assist the designer in selecting the type of storage best adapted to his particular storage problem. It is not only a question of storing the product without loss of volume through evaporation or leakage, but also of, in many instances, preventing deterioration or loss of quality as a result of contact with air, water, dust, or other foreign substances. Classes of service to which each of the five basic types of storage containers are best adapted can be summarized briefly as follows: (1) atmospheric tanks with fixed roof equipped with conservation vent valves are suitable for products of low volatility such as fuel oils, kerosene, or heavy crude oils; (2) tanks with roofs that provide a variable volume vapor space are used most advantageously in these ways: A. Breather

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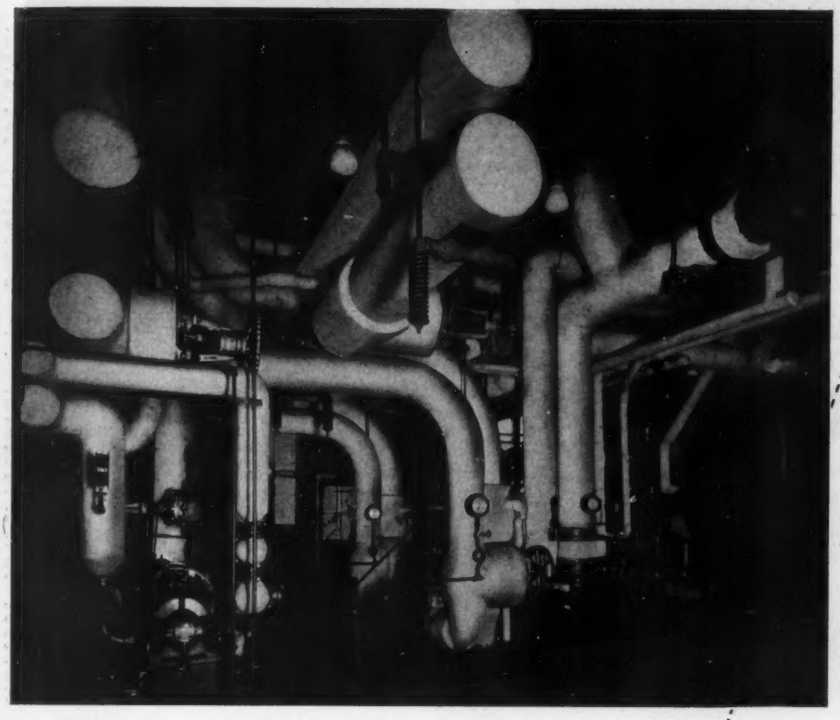

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roofs provide economical storage for light products such as motor gasoline or light crude oils in tanks that normally remain full or nearly full; B. Balloon roofs which have a relatively large volume afford the lowest cost storage for motor gasolines and similar products in slow working tanks that are filled and then emptied gradually over a period of several months; (3) floating roofs provide the most economical means for storing motor gasolines, light crude oils and other products in active tanks which are worked either continuously or intermittently. Floating roofs are also recommended for installations in which reduction in fire hazard is one of the prime considerations in selecting the type of tank; (4) pressure tanks such as spheres and spheroids afford the only practical method for storing natural gasoline, iso-pentane, butane and other light products that suffer enormous losses from boiling in ordinary storage tanks; (5) underground storage is much more costly than above ground storage and is used primarily for installations in which concealment is necessary for defense purposes or where tanks must be placed below surface to comply with city ordinances.

Products: Properties and Utilization

Synthetic Rubber in Industry, H. H. HARKINS, *Chem. & Met. Engr.* **49** (1942) pp. 78-82.

The increasing production of synthetic rubber and the rapidly decreasing supply of natural rubber give rise to the question as to how the new types of rubbers can be used for construction of equipment in the process industries. The author discusses the peculiar characteristics of each of the synthetic rubbers that are now being made commercially with special emphasis on their resistance to heat, oxidation, oil and chemicals. Neoprene is resistant to oils, to deterioration by heat and oxidation, to gas diffusion, and it has a long flexing life. It is therefore used for such products as hose, gaskets, transmission and conveyor belts, boots where oil is a factor, soles and heels where an oily condition exists, tank linings where oil or high temperatures are encountered, and soft roll covers, particularly printers' rolls. Perbunan or Buna N is a copolymer of butadiene and acrylonitrile. In vulcanized form it is resistant to aliphatic oils, quite resistant to heat, and has low permanent set and good cold flow resistance. This rubber can be used for printers' rolls, motor mountings, conveyor belts, gasoline hose, packing, gaskets, and similar products. The rubber Buna S is a copolymer of butadiene and styrene and resembles natural rubber. It is not oil resistant, but does have a good resistance to abrasion and chemicals, and has good electrical properties. Buna S can be bonded to metal satisfactorily and hence may prove useful as a tank or pipe lining material to replace rubber for resistance to chemical solutions. The Thiokol, or polysulphide rubbers, are best known for their exceptional resistance to oils —both aliphatic and aromatic. They are resilient, but have poor resistance to high temperatures and severe mechanical stresses. Thiokols are excellent for hose, printers' rolls, gaskets, self-sealing gasoline tanks, and other mechanical goods where high resistance to oil is required. A table is presented by the author showing a comparison of the properties of synthetic rubbers. From this table it is possible to select suitable rubbers for given purposes.

Electrical Bitumens—Part 1, E. E. HALLS, *The Industrial Chemist,* February, 1942, pp. 51-54.

The plastic masses known as bitumens, asphalts and pitches have long been employed in the electrical industry. Research over the last twenty years has made available a much wider range of products, new properties have been discovered, and a higher degree of refinement is now possible. These materials are employed in the electrical industry for impregnation and sealing, potting and filling, and particularly in connection with equipment such as condensers and small coils, transformers and cables. Bitumens are very different from waxes, as they do not melt sharply to mobile fluids. They possess a wide melting range, below which they gradually flow even without applied pressure, while above it they are highly viscous fluids. The penetration and melting point characteristics of ordinary petroleum bitumens, of Continental bitumens, and of bitumen-wax mixtures, are described and discussed in relation to the application of the material. The author feels that too much stress cannot be laid upon the merits of the wax mixtures with their low temperature manipulability combined with resistance to cold flow.

Determination of Mixed Aniline Points of Hydrocarbon Solvents, B. H. SHOEMAKER AND J. A. BOLT, *Ind. & Eng. Chem., Anal. Ed.* **14** (1942) pp. 200-201.

Considerable attention has been given to methods of determining the solvency of paint, varnish, and lacquer thinners. Although the viscosity method represents an ultimate means of determining the relative value of various thinners, a simpler test, such as aniline point, will probably continue to be used for controlling the uniformity of a given thinner. With the recent development of petroleum naphthas containing substantial quantities of aromatic hydrocarbons it has been necessary to use a mixed aniline point test. The mixed aniline point has been defined as the minimum miscibility temperature in degrees centigrade of a mixture of 10 cc. of anhydrous aniline, 5 cc. of the thinner under test and 5 cc. of any naphtha whose aniline point is 60° C. The authors have studied the diluting thinner, and from the results of the work given it is evident that the paraffinic diluent used for the determination of mixed aniline points should be defined much more rigidly than it has been in the past. The authors recommend that the diluent be identified by its aniline point and by its mixed aniline point with C.P. toluene.

Dr. Carl O. Johns Dies in Stamford

Dr. Carl O. Johns, consultant chemist and former director of research for Standard Oil Development Company, died of a heart attack on April 17 in Stamford, Connecticut. He was a specialist in petroleum chemistry.

Born in Sweden, Johns came to this country in 1879. He held degrees from Bethany College, Kansas, and Yale, and taught for a number of years in both institutions.

Since 1930 Johns had been a consulting chemist. He was a director of the New Jersey Chemical Society, a fellow of the American Association for the Advancement of Science and a councilor of the American Chemical Society.

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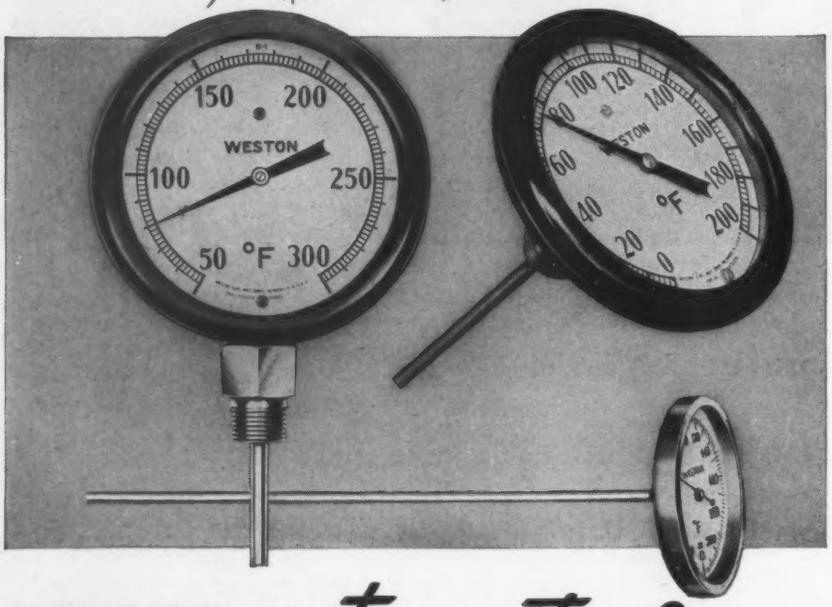

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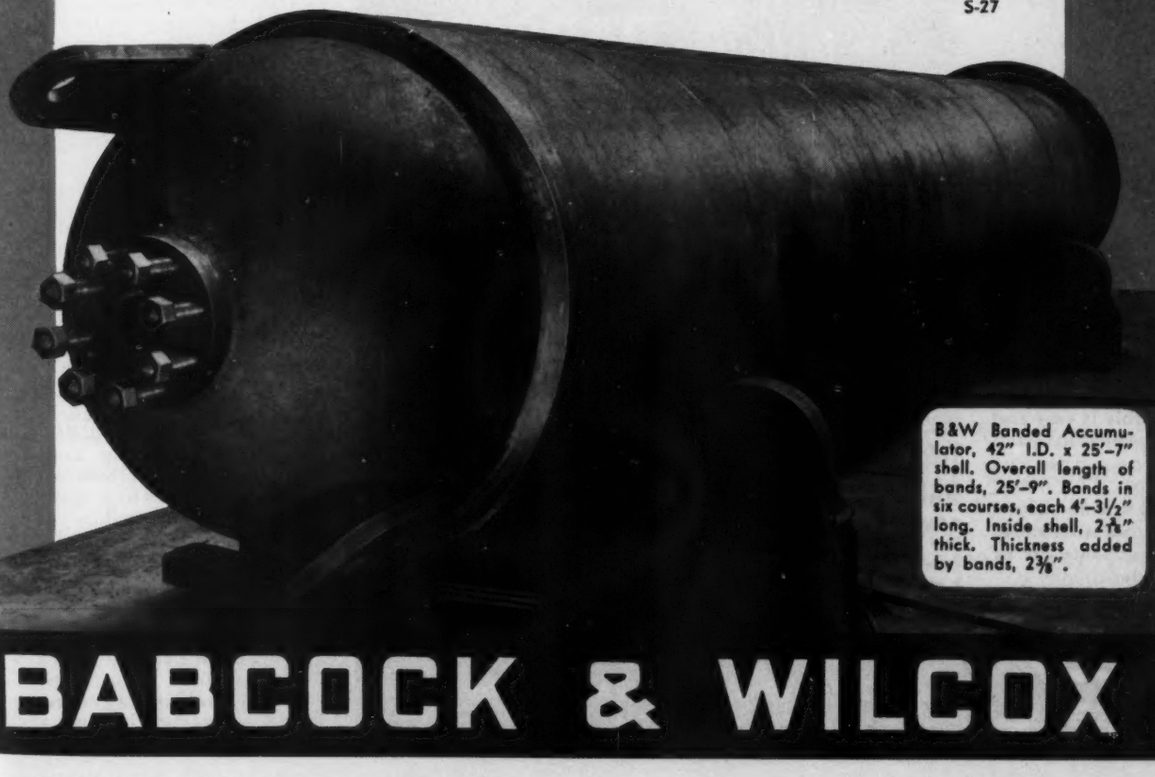

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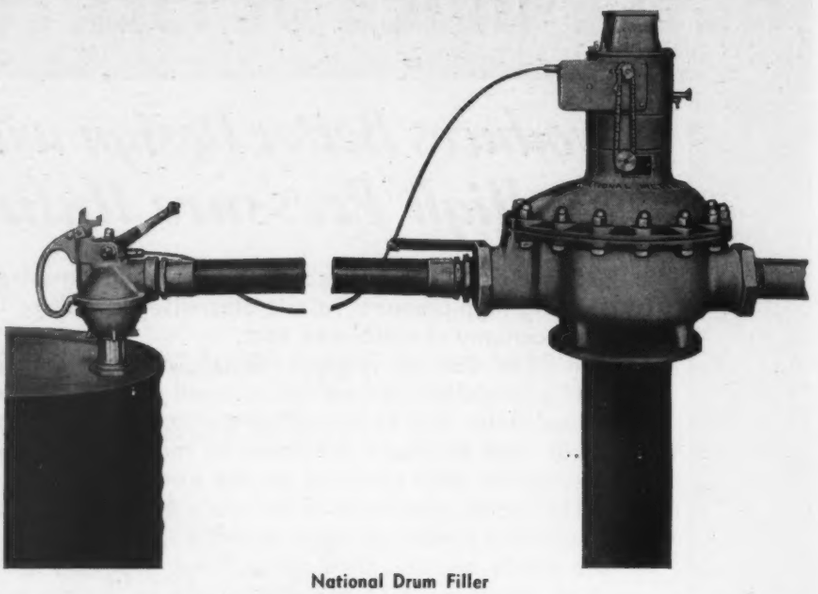
Pittsburgh Equitable Meter Company, National Meter Division, 4207 First Avenue, Brooklyn, has designed a new Empire Thermostatic drum filler.

This unit consists of an oscillating piston, positive displacement meter, a thermostatic microset for automatically correcting the meter measurement to the exact equivalent of the desired volume at 60° F., a repeat register with exterior quantity chain having a fixed cam thereon which trips, and a mechanically operated control valve with non-foaming, dripless nozzle of integral construction.

Changing from one predetermined delivery amount to another is accomplished by simply installing a quantity chain of the proper length on the side of the repeat register. Quantity chains in lengths of from 10 to 100 gallons per cycle can be furnished.

The manufacturer claims that the use of this unit will result in a 100 percent increase in barreling speed over the measure by weight method. It eliminates constant thermometer checking, reference to complicated charts and calculations, and requires no setting and resetting of adjustments for temperature changes.



National Drum Filler

Extinguishing Compound

DU GAS ENGINEERING CORPORATION

DuGas Engineering Corporation, Marinette, Wisconsin, has announced a new dry fire-extinguishing compound, "duMag," a powder developed specifically for extinguishing magnesium and incendiary-bomb fires.

"DuMag" powder is a blend of chemicals in correct proportions to give the desired characteristics. It can be applied directly from the container to the fire, or to the burning bomb, with scoop, shovel, extinguisher, or other mechanical means. It has been tested and approved by the Factory Mutual Laboratories for fires in magnesium alloys.

It is available in 45 pound pails and in 12 pound tubular containers. The quantity in the tube is said to have been proved by actual test to be amply sufficient to extinguish the common 2 pound magnesium-thermit type incendiary bomb.

Differential Transmitter

MOORE PRODUCTS COMPANY

Moore Products Company, H and Lycoming Streets, Philadelphia, has developed a pneumatic differential transmitter for measuring and amplifying small differential pressures and transmitting this value to a meter, calibrated in the units measured.

The outstanding characteristic of the method is the true linear function and constant ratio of amplification. The ratio may be varied to suit specific requirements but in all cases it depends only on a fixed ratio of bellows areas and does not use any mechanical members that might cause friction.

A high-pressure tap connects with the inside of a large bellows and the low pressure tap connects to the opposite

Attention! REFINERS

Your Pumps will Run Longer, Better—with Fewer Shutdowns—by Installing DARCOVA PUMCUPS!

● This is an assembly of a Darling Piston equipped with Darcova Pumcups. This assembly is easy and inexpensive to install in your present pumps. The metal parts are machined to close tolerances for accurate fit of cylinder.

A large producer in Odessa, Texas, reports:

"Tested 4" Duplex Gaso Pump with *Darcova Pumcups* in one cylinder, and metal piston rings in the other. After 140 days, the *Darcova Pumcups* were *still running*, while the *metal rings* had been replaced 3 times!"

Start now to cut your pumping costs. Your pumps, new or old, regardless of present packing will operate with *more* efficiency once this money-saving installation is made with Darcova Pumcups.

Take Advantage of the FREE DARCOVA SURVEY SERVICE

● Darcova engineers can help you get the most from your pumping dollar. Phone, wire, or write—or ask any supply store. Darcova offers a complete line of Pumcups, Pistons, Valve Cups, Balls and Seats, Seating Cups, Seating Rings for oil well and reciprocating pumps.

DARCOVA

THE ORIGINAL COMPOSITION CUP

DARLING VALVE & MANUFACTURING CO.

WILLIAMSPORT, PA.

MOLYBDENUM ENLISTS FOR THE DURATION

The enormous increase in requirements of molybdenum has necessitated the War Production Board Order M-110, placing molybdenum consumption under allocation control...Our metallurgical research staff is fully engaged in war work. At our mine, mill and converting plant, every effort is being made towards maximum production.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE—BRIQUETTED OR CANNED • FERROMOLYBDENUM • CALCIUM MOLYBDATE

Climax Molybdenum Company
500 Fifth Ave. • New York City

MOLY

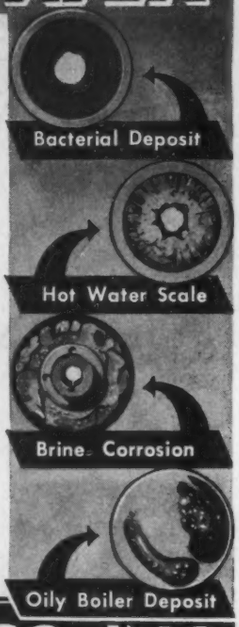
what
WE READ in WATER

There are a great many stories that can be read in the various samples of water we receive. They tell of scale and corrosion in varying degrees of destructiveness. Water for cooling systems, steam and return systems, refrigerating brines . . . each has its particular story. Power plants, petroleum industries, process industries, public buildings and transportation industries . . . all have their problems.

Let us study these problems for you and tell you how Chrom Glucosate, Phospo Glucosate, and many others of our Haering products can correct these conditions, saving your materials and increasing the production of your plant.

Write for these interesting booklets:

"Organic Methods of Scale & Corrosion Control"
"Cooling Waters" • "H-O-H Lighthouse Reprints'
"The Solution of Your Proportioning Problem"
and other booklets on water treatment for Power Plants, Refrigeration Plants, Petroleum Industries, Process Industries, Public Buildings, and Transportation Industries.



D. W. HAERING & CO., INC.
GENERAL OFFICES: 205 West Wacker Drive
CHICAGO, ILLINOIS

Accuracy OF COLOR CONTROL!
Speed IN PRODUCTION!

That's what you get when you use *New Fluorescent Green H W* as an additive to give your lubes that *natural bloom.*

★ ***No tie-up of equipment and extra labor that blending demands.***

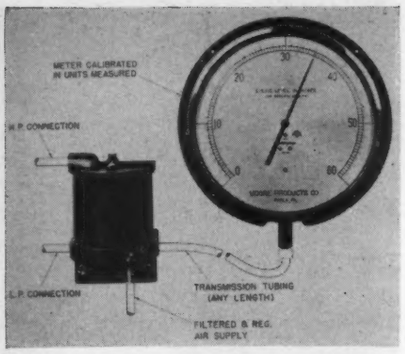
★ ***No loss of efficiency that an extract causes.***

Oils treated with *New Fluorescent Green H W* are stable to light, heat and storage. You obtain cast without affecting fire, flash, pour or carbon tests.

WRITE FOR SAMPLES, PRICES AND INFORMATION

Leading companies have used Wilmot & Cassidy products for more than ten years.

WILMOT & CASSIDY, INC.
108 PROVOST STREET · BROOKLYN · NEW YORK


METER CALIBRATED IN UNITS MEASURED
H. P. CONNECTION
L. P. CONNECTION
TRANSMISSION TUBING (ANY LENGTH)
FILTERED & REG. AIR SUPPLY

side. Regulated and filtered air is admitted through a removable restriction screw into a small bellows chamber inside the large one and this air discharges through the exhaust nozzle in the small bellows. Any increase or decrease of differential pressure across the large bellows moves it to or from the exhaust nozzle, causing an increase or decrease of the air balancing pressure in the small amplifying bellows. This pressure automatically maintains all the bellows in a position of equilibrium with respect to the exhaust nozzle. This is also the pressure which is transmitted to the indicating, recording or controlling meter which may be located at a remote point.

Possible uses are in liquid level, interface level, flow in pipes, ratio flow control, specific gravity, temperature transmission and pressure transmission.

The differential unit is made with phosphor bronze or stainless steel welded bellows according to the application. A separate pilot is provided where long distances of transmission are required.

Reversing Starter

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, has a new line of alternating current combination magnetic reversing starters for full-voltage starting and reversing of squirrel-cage induction motors. They are also suitable for primary control of wound-rotor motors in the single units, which consist of two mechanically interlocked reversing contactors, two-pole overload relay and either a circuit breaker or a fusible or non-fusible motor circuit switch.

The starters are designed to provide full-voltage reversing control and short-circuit protection in one unit to save space and installation time, to provide greater protection for equipment and operators, and to improve appearance. They are completely wired and ready to operate after connection of incoming power lines, outgoing motor lines, and control circuit. The line includes NEMA size 0 to 4 starters covering single-phase and 3-phase motors in sizes up to and including 100 horsepower at 440 or 550 volts.

The fusible forms combine a manually operated motor circuit switch with clips for cartridge-type fuses. Under short-circuit conditions, the fuses provide fast interruption of circuits having maximum available current of 10,000 amperes at rated voltage. The motor circuit switch is operated from the outside of the enclosing case by a handle so interlocked with the cover that the switch must be in the off position before the cover can be opened. This

Conversion TO WAR PRODUCTION CALLS FOR MORE INFORMATION ABOUT ALLOYS...

Conversion to war production makes great demands upon both plants and personnel. While altering plant layouts, experienced employees must be taught correct methods of handling new operations on different metals. New employees must be trained...and taught to avoid waste and spoilage of critical materials.

You can *quickly* obtain practical answers to questions about the selection, fabrication and uses of ferrous and non-ferrous alloys containing Nickel by asking us. We have on hand a fund of information collected through years of research, field studies and experiences of alloy users.

This data has been checked and edited into convenient charts and pamphlets. These printed pieces range from technical data for engineers to simplified guides for apprentices.

Now...with minutes and materials so vital to Victory...make full use of this metal-working experience. Our technical staff also offers personal assistance in overcoming problems created when Nickel was allotted to places where it serves the Nation best.

★ ★ *Nickel* ★ ★

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

. . . Operating Efficiency of Amsco-Nagle Pumps Results from Design Simplicity . . .

The need for conserving vital metals and man-power makes the use of Amsco-Nagle Horizontal and Vertical Shaft Centrifugal Pumps all the more important.

Their simplicity of design effects an operating efficiency that minimizes the replacement cost of bearings, packing and other parts. When such maintenance is necessary, it can be accomplished quickly and easily and without the customary pump dismantling.

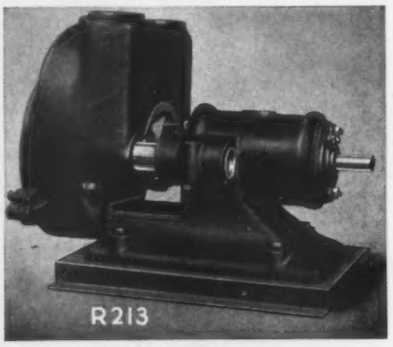
In the horizontal pumps the casing and the bearing stand are held rigidly together by tubular supports. (In the vertical shaft series these tubes also function as discharge pipe and lubricating duct respectively.)

Amsco-Nagle Type "A" Horizontal Shaft Pumps are self-priming without the use of ducts or jets or the need for recirculation. Submerged bearings and their attendant troubles are eliminated in the Type "QW" Vertical Shaft Units. Bearings are supported in a rigid, fully enclosed column. The Types "SD" and "SW" have steadying and intermediate sleeve bearings supported in split yokes which make them simple to replace. They are readily lubricated from above the floor plate.

Impellers, casings, and plates can be made of abrasion or corrosion resistant materials best suited to the liquid or solids in suspension being handled. Impellers of various types are available, depending on the nature of the application. They are screwed onto the shaft, simplifying installation.

Amsco-Nagle Pumps are available in capacities in the range of 7,000 g.p.m. for heads of 200′. Vertical shaft units are available for wet or dry pit application. Horizontal types can be furnished with pulley or for direct connection.

Check the design and operating advantages of these sturdy pumps for the chemical and processing industries; determine for yourself how they can help save time and cut costs during this critical period—send for Bulletin 940.



Note accessibility of stuffing box on this Amsco-Nagle 1½" Type "A" Frame 7 Horizontal Pump (R213). Casing can be removed after loosening nuts on bolts clamping the tube supports.

Impeller is screwed on. Water end on horizontal pumps held on by three clamp-dogs. This is a 2" Type "T" Frame 10 unit (R222).

Pumping end, bearings and floor plate are rigidly tied together by tubular members which also function as discharge pipe and lubrication duct, respectively, in this 2" Type "SW" Frame 10 Amsco-Nagle vertical shaft pump (R282) which has a setting (or submergible length) of 14 ft.

R282

Amsco

AMERICAN MANGANESE STEEL DIVISION
OF THE AMERICAN BRAKE SHOE & FOUNDRY CO.
Chicago Heights, Illinois

Manganese Steel Castings for shocks and abrasion.
Chromium-Nickel Alloy Castings for heat and corrosion resistance.
Power Shovel Dippers. Dredge and Industrial Pumps.
Welding Materials for reclamation and hard-surfacing.

FOUNDRIES AT CHICAGO HEIGHTS, ILL.; NEW CASTLE, DEL.; DENVER, COLO.; OAKLAND, CALIF.; LOS ANGELES, CALIF.; ST. LOUIS, MO. OFFICES IN PRINCIPAL CITIES

makes it impossible for an operator to attempt to make adjustments on the inside of the enclosure without first opening the circuit.

The circuit breaker forms provide simultaneous tripping of all phases on short circuits, and have a trip-free mechanism which prevents holding the breaker closed under short-circuit conditions. The breaker can be reset after operation by returning the operating handle to the off position. Breakers in the smaller ratings have bimetal thermal trip units only and the larger breaker ratings have interchangeable bimetal thermal trips as well as magnetic instantaneous trips.

When the starters are used in conjunction with a momentary contact push-button station, undervoltage protection is provided by an electrical interlock on each contactor. An isothermic temperature overload relay protects the motor from dangerous overheating caused by overloads or other conditions.

The contactors have layer-wound coils, molded arc chutes, and readily accessible contacts, and are mechanically interlocked so that only one contactor can be closed at a time. The starters are available in Type 1 general-purpose enclosures, Type 1A semidust-tight enclosures, Type 5 dust-tight enclosures, or Type 4 water-tight enclosures.

Identification Material

AVERY ADHESIVES

Avery Adhesives, 451 Third Street, Los Angeles, has developed a substitute material "Kum-Kleen," for use instead of metal identification plates and tags. The manufacturer gives the following information:

"This product adheres permanently to any smooth surface including glass, plastics, enamel, varnish and wood and is applied without moistening. It will adhere when exposed to high temperatures or changing climatic conditions.

"Application can be made without drilling, tapping or riveting."

Special Alloy

JESSOP STEEL COMPANY

Jessop Steel Company, 578 Green Street, Washington, Pennsylvania, announces a new product "TCM High-Speed Steel." It replaces 18-4-1 and is of particular importance now due to the shortage of strategic alloys. It is a low tungsten-molybdenum steel and cuts as well, or better than 18-4-1.

There is no change in operating equipment necessary in using this product because it is heat treated in the same furnaces and the same atmosphere as 18-4-1 high-speed steel. TCM steel has a slightly lower hardening temperature which contributes to a lower cost in heat treating.

Watthour Meter

WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY

Westinghouse Electric and Manufacturing Company, East Pittsburgh, is introducing a new switchboard watthour meter, Type CB, for industrial as well as switchboard use.

The units are available for metering all combinations of single-phase or polyphase power. Mounting styles are flush, projection and a detachable or plug-in construction. The detachable models

IF UNCLE SAM IS CALLING YOUR EMPLOYEES

You must have greater efficiency in your plant

MAXIMUM
Decolorizing Efficiency

MAXIMUM
Filter Rate

MINIMUM
Clay Requirements

MINIMUM
Plant Equipment

FULL DETAILS
ON REQUEST

LABOR SHORTAGES are becoming acute on every hand, as men are called to the armed forces and women join the defense industries. If this problem has not hit you yet, it almost certainly will do so in the near future.

That's where SUPER FILTROL can do you a real favor. It saves labor and operating costs all along the line. SUPER FILTROL increases lube plant production, promotes greater efficiency and makes you a real silent partner of Uncle Sam.

FILTROL CORPORATION

GENERAL OFFICES:
315 WEST FIFTH STREET
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PLANTS:
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CABLE ADDRESS: FILTROL·LOS ANGELES

AGENTS AND WAREHOUSE STOCKS IN PRINCIPAL REFINING CENTERS OF THE WORLD

can be readily removed for overall inspection and test without interrupting the circuit. All the calibration adjustments are accessible from the front when the molded glass covers are removed.

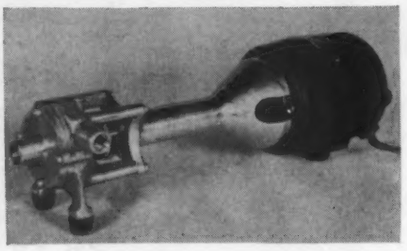
The CB single-phase meters in this line have one electro-magnet and are applicable to single-phase circuits. The CB meters for the usual 3-wire single-phase circuits have 3-wire current coils. CB-2 meters have two 2-wire elements and may be used on single- or 3-phase, 3-wire circuits, and on 2-phase, 3- or 4-wire circuits. CB-3 meters consist of three 2-wire elements. They are used to meter 3-phase, 4-wire star-connected circuits and, when used with instrument transformers, to totalize combined 3-phase, 3-wire and single-phase, 2-wire or 3-wire loads.

The CB-8 meters are of the two disk type and have two 3-wire electromagnets interconnected to form a 3-current coil meter. These are used on 3-phase, 4-wire star-connected service and are fully accurate wherever the voltages are not extremely unbalanced. CB-10 meters are of the two-disk type and have two separate 3-wire elements. They are used on 2-phase, 5-wire service.

Midget Hot Liquid Pump

EASTERN ENGINEERING COMPANY

Eastern Engineering Company, 45 Fox Street, New Haven, Connecticut, has designed a small pump for handling hot liquids up to 500° F. It is designated model EH hot-liquid pump.



Eastern Midget Pump

It can be used in industrial, pilot plant, laboratory and experimental applications. The unit is a centrifugal type, weighing 67 pounds, powered by a 1/20-horsepower fan-cooled motor, 115 volts. Motor and pump are coupled through a 5-inch heat-radiating tube and the shaft is supported by outboard ball bearings.

Pour-point Depressant

MONSANTO CHEMICAL COMPANY

Monsanto Chemical Company, Organic Chemicals Division, St. Louis, has announced an improved pour-point depressant for use in heavy wax-bearing paraffinic lubricating oils, Santopour.

A synthetic material closely resembling a petroleum lubricant in physical properties, "Santopour" is designed to enable the refiners of wax-bearing crudes to produce low-pour-test oils more economically by avoiding the expense of dewaxing at extremely low temperatures. Good economy and satisfactory results have been achieved by dewaxing to a pour point of 15 to 25° F. and then using Santopour to further reduce the pour point to the required degree. Santopour is effective in a number of different types of oils.

Texas Company Closes West Dallas Refinery

The Texas Company refinery at West Dallas, Texas, shut down May 1. The refinery, which has a 20,000-barrel crude capacity, is the second the company has closed. Operations ceased at the company's Houston plant recently.

In making the announcement, Leach said the personnel will be greatly reduced, but every effort will be made to transfer as many as possible to other company plants.

Closing of the unit was blamed on "continued tanker losses and diversion, and gasoline rationing." The company has 14 other refineries in the United States.

Large New York engineering firm requires chemical engineers; age preferably 25-30 with any following experience:

1. Petroleum refinery experience in operation or design of stabilizers, absorbers and light end equipment.

2. Refinery experience in design or operation of plants for solvent dewaxing and solvent extraction of lube oils.

3. Refinery experience in design or operation thermal or catalytic cracking plants. In reply state education qualifications and refinery experience in detail. Also salary expected and status regarding military service. Box 333, c/o The Refiner, Houston, Texas.

* FOR **Proven** *performance!*

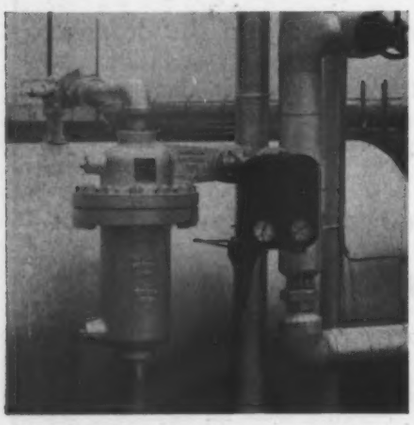
SPECIFY H-W Type 850

DISPLACEMENT TYPE

LEVEL CONTROLLER

THE ONLY LEVEL CONTROLLER WITH

N STUFFING BOX
. . . . . LEAKAGE
. . . . . FRICTION



***ASK THE MEN WHO OPERATE THEM**

Information on all HANLON-WATERS Equipment available at representative nearest you

HANLON-WATERS, INC.

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Steel VALVES!

Cast and Forged

Cast Iron VALVES —Standard and High Pressure

Every Type Used in an Oil Refinery

All Expertly Reconditioned and GUARANTEED to Perform Like New.

No Delays

Immediate Delivery

YOU SAVE 25% TO 40%

Over Cost of New Valves

For 8 years, a division of our plant has specialized in reconditioning valves for major oil companies and the U. S. Government. Our shops are equipped with the most modern and efficient tools and facilities for rebuilding valves. Every valve has been expertly reground, reseated, repacked and hydrostatically tested. GUARANTEED to give same service as new valves.

DON'T DELAY. Order your valve requirements NOW and save 25% and more! We can also make immediate shipment of reconditioned flanges — ells — tees — and other fittings at savings of from 25% to 40%. Order TODAY.

Brown-Strauss Corporation

1446 Guinotte . . . . . Kansas City, Mo.

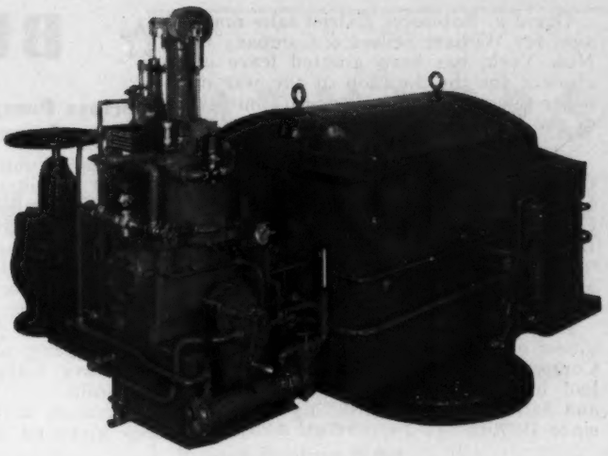
MURRAY

TYPE UV MULTI-STAGE

Low Pressure Turbine

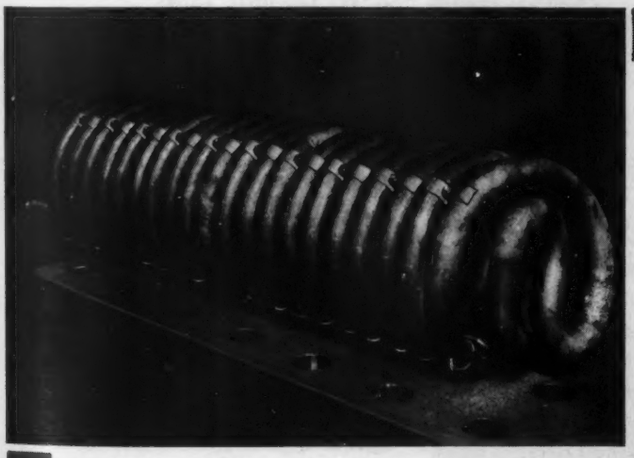
FOR

HOT OIL PUMP DRIVE



Where waste exhaust steam is available, your auxiliary units, such as hot oil pumps, may be driven by low pressure condensing turbines such as shown above. This unit is rated 950 H.P., 4850 R.P.M., and operates with 5 lbs. initial steam pressure and 27" of vacuum. It has six rateau stages and is equipped with variable speed oil pump oil relay governor in the oil control line of which may be installed automatic control to maintain constant pump capacity with increasing head at the pump discharge. Steam inlet is 10" and exhaust outlet is 30" which may be arranged downward as shown, or vertically upward.

MURRAY IRON WORKS COMPANY... BURLINGTON, IOWA



WHITLOCK COILS

Whitlock Coils are backed by a staff of trained Engineers and an unparalleled experience of over 50 years of coil making and over 30 years of designing and manufacturing heat exchangers of all types. These Engineers are ready to help you with your coil problems — or our manufacturing department will fabricate coils to your own design.

Materials: Whitlock Coils are made of pipe or tubing of any material — standard or special alloy — that can be coiled.

Testing: Whitlock coil testing facilities are unusual — up to 10,000 lbs. hydrostatic pressure or up to 4500 lbs. by "air under water" method.

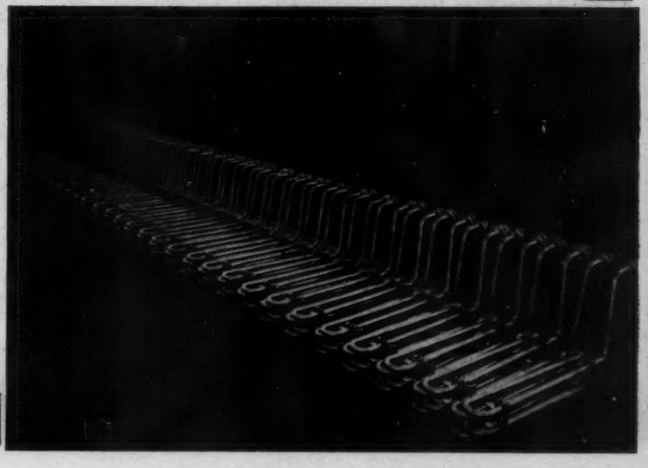
Bulletin 92 illustrates and describes Whitlock Coils — an unusually complete coil bulletin.

THE WHITLOCK MANUFACTURING CO.

75 South St. **Elmwood, Hartford, Conn.**

District Offices in

New York Chicago Detroit Boston Richmond Philadelphia



☆ BUSINESS NOTES ☆

David F. Robinson, district sales manager for William Sellers & Company in New York, has been granted leave of absence for the duration of the war in order to serve in the aeronautics bureau of the United States Navy.

Fred Crabbe, who has been in the Corpus Christi territory for Manning, Maxwell & Moore, Inc., Bridgeport, Connecticut, has been transferred to the Dallas office, where he will cover territory formerly covered by Alfred Kent, who is now in military service.

Robert F. Vogt, chief consulting engineer of Allis-Chalmers Manufacturing Company, Milwaukee, died April 17. He had been with the company 36 years and had been chief consulting engineer since 1937.

Peerless Pump Acquires Sterling Pump Corporation

Peerless Pump Division of Food Machinery Corporation, Los Angeles, has bought Sterling Pump Corporation, with plants at Hamilton, Ohio, and Stockton, California. In the consolidation the Sterling plant at Hamilton will become a part of the new Peerless plant at Canton, Ohio. The Stockton plant will be combined with John Bean Manufacturing Company, also a division of Food Machinery Corporation, at San Jose, California.

Engineers at the Canton plant have been given an assignment to design a straight-line-assembly department for the manufacture of the small products line of the Sterling unit.

Personnel of the Sterling organization will take over duties with Peerless. H. J. McKenzie, president of Sterling Pump Corporation, has been named assistant to Vernon Edler, vice president of Peerless Pump Division. Fred Jones, manager of the New York office, will continue in the Peerless organization. John Mikesell, former engineer of the Sterling plant, will be manager of the small-parts line. Jack Wade, chief engineer, has been given charge of new development at the Canton plant.

Currier Heads Tubular Exchanger Association

Charles E. Currier, vice president of Ross Heater & Manufacturing Company, has been elected president of the Tubular Exchanger Manufacturers' Association. Other officials are W. C. Beckley, vice president, and W. J. Parker, secretary-treasurer, reelected.

In addition to Ross Heater & Manufacturing Company, members of the association are: Foster-Wheeler Corporation, Alco Production Division of American Locomotive Company, Henry Vogt Machine Company, Whitlock Manufacturing Company, Griscom-Russell Company, Struthers-Wells Manufacturing Company, The Lummus Company and M. W. Kellogg Company.

Headquarters are at 366 Madison Avenue, New York.

C. W. Dermitt Joins Pennsylvania Salt

C. W. Dermitt is now with the sales division of Pennsylvania Salt Company in connection with the distribution of heavy chemicals. He will have headquarters in the Pittsburgh office. Until recently he was in the Pittsburgh territory for Pennzoil Company and previously was associated with People's Pittsburgh Trust Company.

McLean Joins Vapor Recovery Systems

Thomas McLean has been appointed chief engineer of Vapor Recovery Systems Company, Compton, California. He is a graduate of the University of Iowa, whose experience in the petroleum industry includes pipe-line, power-plant operation, tank-construction and venting equipment. The company is a manufacturer of tank venting and other equipment.

Corrigan Takes Over Alco Diesel Sales

W. E. Corrigan, vice president of American Locomotive Company in charge of munitions and miscellaneous sales, has assumed additional duties as head of diesel engine sales, according to an announcement by Duncan W. Fraser, president. Diesel locomotive sales remain under the supervision of Perry T. Egbert.

Corrigan, who was a captain in the artillery ordnance branch of the Army during the last war, has participated in the negotiation of various recent government contracts with American Loco-

NOW THAT TIME MEANS SO MUCH CLEAN TUBES *FASTER* WITH WILSON TUBE CLEANERS

In this war petroleum products of the highest quality and in ample quantities are *essential*. There *must* be a speeding up of production and processing for "Time is short" indeed. Every hour—yes, every minute—of "down-time" which can be saved is of the greatest value. Every avoidable delay in processing *must* be eliminated in the interest of our national welfare.

Because Wilson E P (Extra Power) Tube Cleaners clean *faster*, they *reduce* "down-time;" because they clean *better*, they *increase* the time a still or other refinery unit can remain on stream. They thus *increase* the production of vital petroleum products.

There is a Wilson Tube Cleaner, cutter head, or other accessory for every refinery tube or pipe cleaning job. Write for the name of our representative nearest to you or send for a copy of our NEW forty page catalog fully describing and illustrating the complete line of Wilson tube cleaning equipment.

THOMAS C. WILSON, Inc.
PIPE AND TUBE CLEANERS EXCLUSIVELY
47-28 37th Street Long Island City, N. Y.

To all

Natural Gasoline Men

Greetings from the

Natural Gasoline Supply Men's Association

We are looking forward to seeing you at the

TWENTY-FIRST ANNUAL CONVENTION OF THE

NATURAL GASOLINE ASSOCIATION OF AMERICA

May 14-15, Mayo Hotel, Tulsa, Oklahoma

MEMBERS

of the

NATURAL GASOLINE SUPPLY MEN'S ASSOCIATION

The American Rolling Mill Company
The Bristol Company
The Brown Instrument Company
Butane-Propane News
Chaplin Fulton Manufacturing Company
Chicago Bridge & Iron Company
Clark Brothers Company
Continental Supply Company
Cooper Bessemer Corporation
Joseph A. Coy Company
W. H. Curtin & Co.
The Fisher Governor Company
The Foxboro Company
Frick-Reid Supply Corporation
Gasoline Plant Construction Corporation
Goulds Pumps, Inc.
D. W. Haering & Co., Inc.
Hanlon-Waters, Inc.
Hercules Motors Corporation
Ingersoll-Rand Company
Warner Lewis Company
Mason-Neilan Regulator Company
C. A. Mathey Machine Works
Merco-Nordstrom Valve Company
Metric Metal Works
Mid-Continent Engineering Company
Midwest Piping & Supply Company
Moorlane Company
National Petroleum News
National Tank Company
Naylor Pipe Company
The Oil & Gas Journal
The Petroleum Engineer
Petroleum Engineering, Inc.
Pittsburgh Equitable Meter Company
The Refiner & Natural Gasoline Manufacturer
The Refinery Supply Company
Taylor Instrument Companies
Tulsa Boiler & Machinery Company
Vinson Supply Company
Walco Engineering & Construction Company
Westcott & Greis, Inc.
Woobank Pump & Machinery Company
Worthington Pump & Machinery Company
Wyatt Metal & Boiler Works
John Zink Company

motive Company for production of ordnance and other war materials. The company is making tanks, gun carriages, marine diesel engines, shells, bombs, and heavy forgings. He started with the company in 1909, completed a four-year course in locomotive construction at its Schenectady plant.

Howard W. Broecker has been appointed assistant manager of the Chicago district for Copperweld Steel Company, Warren, Ohio. He was previously with Youngstown Sheet and Tube Company in Chicago as well as with Interstate Iron and Steel Company.

Craddock Now with Edge Moor Iron Works

F. L. Craddock has been appointed sales manager of mixing and process equipment for Edge Moor Iron Works, Inc., Edge Moor, Delaware, where he will make headquarters. He formerly was president of Mixing Equipment Company, Rochester, New York.

Buchanan Resigns as Allis-Chalmers President

Because of ill health, W. C. Buchanan has resigned as president of Allis-Chalmers Manufacturing Company, Milwaukee. He underwent a series of operations recently and on the advice of his physician decided to reduce business activities for an indefinite period.

He retains his memberships on the board of directors and the executive committee, positions he has held for several years.

Directors have elected Walter Geist to the position of executive vice president. He has been with the company since 1909 and has been vice president. The presidency will not be filled until after the annual meeting in May.

Mathieson to Build New Ammonia Plant

Mathieson Alkali Works, New York, will build a new ammonia plant, which will be financed by the Defense Plant Corporation and operated under lease by the Mathieson organization. Ammonia will be produced synthetically through the use of a modification of existing methods by combining hydrogen with nitrogen obtained from the atmosphere.

Additional Plant Facilities Added

Chamberlain Engineering, Ltd., a unit of United States Stoneware Company, has purchased an existing plant at Ravenna, Ohio, which will be converted to facilities for the manufacture of Tygon, the rubber-like synthetic used for lining piping and tankage.

Separate buildings will be devoted to synthetic resin manufacture, corrosion-resistant linings for the chemical and process industries, protective paints and coatings, metal and alloy fabrication, non-corrosive cements. Manufacture of these products will be transferred to Ravenna from Tallmadge, Ohio.

R. W. McClenahan Joins Armed Forces

R. W. McClenahan, manager of the Philadelphia plant of American Meter Company, has been granted leave of absence and has joined the United States Army as a major. He has been manager of the plant since 1936.

Oakite Staffs Hold Production Conference

As a means of exchanging information on cleaning and related manufacturing operations, especially in war production, the field, mechanical engineering, chemical research and general headquarters staffs of Oakite Products, Inc., held simultaneous conferences during April in New York, Chicago and Los Angeles.

Sessions of the program of each division conference were devoted to the discussion of improved ways to speed-up output of airplanes and motors, shells, cartridge cases, guns, tanks, bombs, fire-control instruments, communication equipment, helmets and a wide range of ordnance matériel and war supplies.

In addition to these and related production operations, each conference reviewed specialized methods and procedures for effectively handling some of the principal new cleaning problems regarding equipment maintenance and plant safety that war conditions are bringing to petroleum producers, oil refineries, natural gasoline plants and pumping stations.

Topics discussed from these standpoints include shortening down-time for required maintenance on heat exchange

for

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A complete line of Powell Valves for refinery, pipe line and production needs.

See Powell Valve advertisement on page 169.

BELOW: Corbett-Wallace Corporation warehouse. It is well stocked with the latest facilities for expediting shipments to our customers.

ABOVE: New office building . . . completely staffed and equipped for handling business and technical data.

The CORBETT-WALLACE CORPORATION.

Quality Products Plus Engineering Assistance

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Now . . . when repairs are hard to get, and costly, many corrosion problems will be no longer tolerated as a "necessary evil." Of necessity, refinery management will deal with these problems—however small—quickly and thoroughly; thus, in the future the loss of valuable equipment, man-hours and production will be reduced. And new emphasis will be placed on the application of specific equipment for specific purposes.

As in the past 25 years we stand ready to help solve corrosion problems. We represent the leading manufacturers of corrosion resisting pumps, pipe, valves, fittings and tanks. Any equipment we recommend is scientifically constructed and proved, and will be applied with knowledge based on actual experience.

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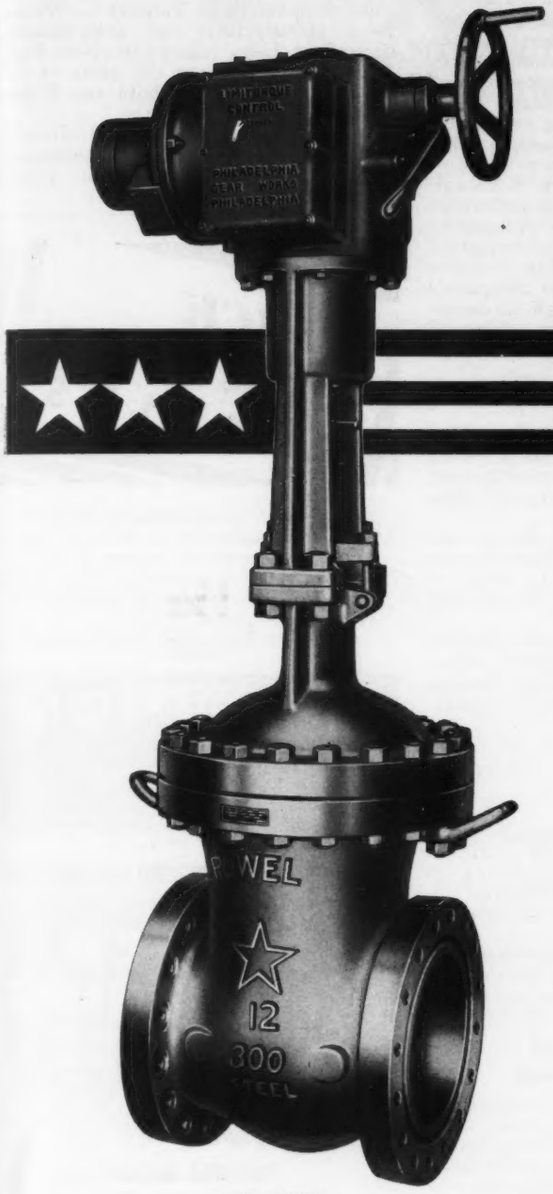

Fig. 3021

Essentially—a valve for the Oil Industry. It is a Class 300-pound Cast Steel, Flanged End Gate Valve, especially designed and constructed for high-temperature cracking or catalytic process work. Equipped with top mounted Limitorque motor operator. Assuring long, uninterrupted service with minimum maintenance, this is one of the many Powell Valves destined for an important role in the "Battle for Victory."

There's many a valve on a submarine, a cruiser, a battleship, or a freighter. There's many a valve in a powder plant, a refinery or a power plant. Wherever War Production is in full blast there are valves, and wherever new processes are being used which involve new treatment of the liquids and gases of Industry, new valve installations are being designed and built to handle them.

Twenty-four hours a day, seven days a week, Powell Engineers, Designers and Shopmen are devoting themselves to this task. Behind them is a century of experience, the skill which comes with it and a research engineering laboratory full of up-to-the-minute equipment. The builders of America's ships, refineries and arsenals will not forget Powell's contribution of Valves for Victory.

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Cincinnati, Ohio

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IT'S LAYNE WATER SYSTEMS FOR THE ARMY, NAVY & WAR NEEDS

Built under extreme emergency and with amazing speed, thousands of Layne Wells and Pumps are providing billions of gallons of water for war needs—Army Camps, Flying Fields, Naval Stations, Ordnance Works, Chemical Plants, Munition Plants and numerous fortified outposts. Though built with utmost speed, those Layne Water Systems have the strength and ruggedness which will last for years and years.

Layne Well Water Systems, regardless of when, where or how speedily built, are the finest that can be constructed. They will faithfully fulfill their mission until victory comes, whether this year, next year or years from now.

Those men of the Army, Navy and Marine Corps who some day will return to civilian life may well remember that it was Layne who built the well water systems which helped to win the war.

In the meantime, essential civilian water supply service continues. The Layne organization is fulfilling its pledge of "Keep Them Flowing!"

LAYNE & BOWLER, INC.
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PUMPS & WELL WATER SYSTEMS

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Layne-Louisiana Company	Lake Charles, La.
Layne-New York Co.	New York City.
Layne-Northwest Company	Milwaukee, Wis.
Layne-Ohio Company	Columbus, Ohio
Layne-Texas Company	Houston, Texas.
Layne-Western Company	Kansas City, Mo.
Layne-Western Co. of Minn.	Minneapolis, Minn.
Layne-Bowler New England Corp.	Boston, Mass.
International Water Supply, Ltd.	London, Ont.

equipment such as oil coolers, preheaters, steam generators and dephlegmators through efficient cleaning practices; safely de-scaling water jackets and cooling systems of Diesel engines, compressors and condensers; reconditioning oil drums; steam cleaning heavy equipment to facilitate inspection and overhaul; and improved salvage cleaning methods for reclaiming valves, fittings, pumps, gears and various other machinery and non-machinery items.

According to J. A. Carter, Assistant-to-the-President, this Oakite conference provided a means of quickly exchanging information on all phases of industrial cleaning that is made readily available through the medium of the company's nation-wide field service staff to executives responsible for refining equipment maintenance.

Tube-Turns Opens Office in Houston

Tube-Turns, Inc., manufacturers of welding fittings and forged steel flanges, Louisville, has opened a branch office in Houston.

W. B. Whenthoff, who formerly was in charge of the Tulsa office for the company, is in charge of the Houston branch. His headquarters are at 1707 Commerce Building.

W. E. Geiser has been named district manager of the Philadelphia office, which is in the Broad Street Station Building. He has been with the organization since 1929.

Rose Promoted in Marsh Organization

A. D. Rose, who has been sales manager of the James P. Marsh Corporation, Chicago, has been promoted to assistant general manager. The new position was created because of enlarged activities of the company.

James Emmett, Jr., who has been assistant sales manager, has been named sales manager.

H. E. Doughty Promoted By Jessop Steel Company

H. E. Doughty has been appointed assistant sales manager of Jessop Steel Company, Washington, Pennsylvania. Formerly district manager at Philadelphia, Doughty's new position was created by a program of expansion. Doughty joined Jessop in 1932 as a sales representative and previously had a number of years experience with other manufacturers in selling tool steels, stainless steels and special high-grade steels.

Brown-Strauss Provides Reconditioned Valves

Brown-Strauss Corporation, 1446 Guinotte Street, Kansas City, has added a valve reconditioning service to its shops, from which the refining industry may purchase equipment. Steel, cast and forged, and cast-iron valves of all types used in refining and put in condition to give service equal to new equipment. A similar service also applies to flanges, ells and tees.

Before offering valves each one is reground, reseated, repacked and hydrostatically tested.

This equipment is not subject to priority requirements.

Eugene K. Ingalls with Thomas C. Wilson, Inc.

Eugene K. Ingalls has joined the sales department of Thomas C. Wilson, Inc., manufacturer of tube-cleaning equipment, Long Island City, New York, He is well known to the users of this type of equipment in both the United States and Canada.

Ingalls is a graduate of the University of Minnesota, 1923, and is a member of the National Association of Power Engineers.

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